Proceedings of the

SKIPJACK TUNA

CONFERENCE

July 1976

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FOREWORD

CONFIRMATION of the presence of substantial quantities of skipjack tuna off the coast of New Zealand and the efforts being made to establish a large-scale fishery based on this resource have been the subjects of much comment and criticism.

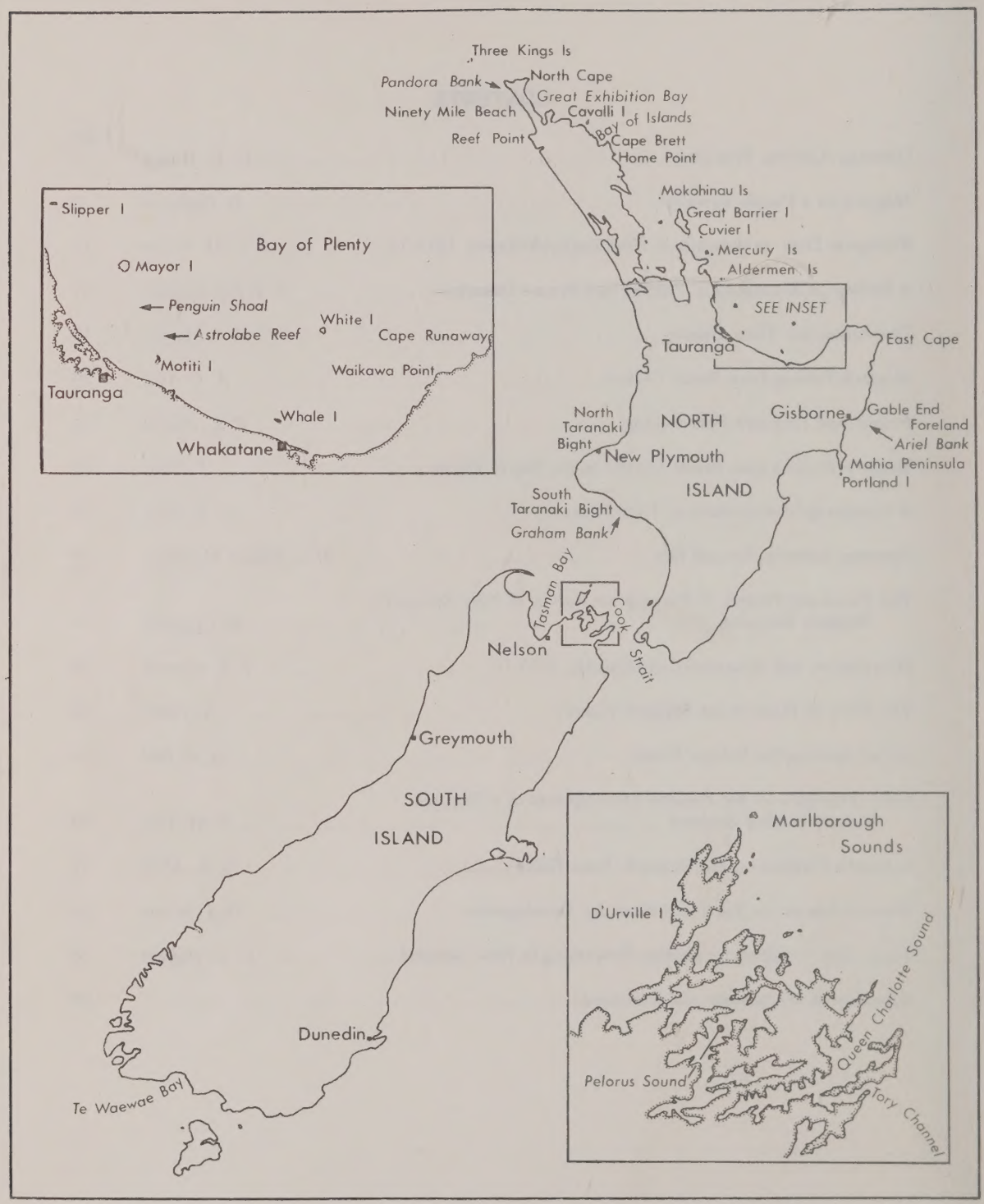
I hope that this report will help to clarify issues and allay some of the fears that have been expressed.

The meeting was set up for the benefit of industry and others, including the scientists from Fisheries Research Division. Its success was due largely to the efforts of Dr George Habib. To him and his colleagues who assisted him, to the speakers and chairmen, and to all who participated in discussions, I would like to express my thanks.

G. D. Waugh
Director, Fisheries Research Division

CONTENTS

		Page
Opening Address, First Day	*G. D. Waugh*	7
Skipjack as a Pacific Resource	*D. Eggleston*	8
Biological Data on Skipjack in New Zealand Waters, 1973-76	*C. M. Vooren*	12
A Review of Management Policies and Future Objectives	*B. T. Cunningham*	17
The Australian Tuna Fishery	*G. I. Murphy*	19
Skipjack Fishing from Small Vessels	*A. G. York*	20
Pirimai and Live-bait Pole Fishing	*P. E. Roberts*	22
Skipjack Fishing from Small Vessels in the Bay of Plenty	*J. Plews*	25
A University Contribution to Tuna Research	*E. B. Slack*	26
Opening Address, Second Day	*Hon. Duncan MacIntyre*	29
The *Paramount* Project: A Purse Seine Survey of New Zealand's Skipjack Resource	*D. Eggleston*	31
Distribution and Abundance of Skipjack, 1975-76	*I. T. Clement*	36
The 1975-76 Purse Seine Skipjack Fishery	*G. Habib*	40
Aerial Spotting for Pelagic Fishes	*G. R. Bell*	47
Some Thoughts on the Possible Development of a Skipjack Fishery in New Zealand	*P. M. Vela*	49
Sanford's Outlook on the Skipjack Tuna Fishery	*N. L. Mills*	51
Wattie's Interest in Tuna and Plans for Development	*G. J. Wattie*	54
Tuna: The Problems for Further Processing in New Zealand	*C. C. Hufflett*	56
Summary of Discussions and Comments		59



Geographical locations mentioned in some of the papers.

Opening Address, First Day

G. D. Waugh

Director, Fisheries Research Division, Ministry of Agriculture and Fisheries, Wellington

It is my pleasure to welcome you to this conference and to introduce the topic.

In view of the controversy over the use of American purse seiners to take "our" fish you may have wondered at our motive for setting up this meeting. You may also have wondered why we chose to hold it now while there is still uncertainty about how a skipjack tuna industry might be, or could be, developed.

Our motive is quite simple. During this conference we want to tell you what we in Fisheries Research Division know about skipjack and what we believe we may discover and to answer as many questions as we can about skipjack both as a fish and as a resource.

It seemed appropriate to ask industry members involved to contribute their observations and opinions so that we could get indications whether our work is, or is likely to be, of importance. We hope that most of the answers we seek will coincide with your needs. If they do not, we want to know and if possible we will change our programmes. This is why we are holding the meeting in July, well before the start of the next season. We chose Tauranga because it is in the centre of skipjack fishing in New Zealand.

The conference is also a forum for the exchange of ideas and information among the various industry sectors. It seems to me that there is a better chance of understanding and appreciation of one another's problems if these are discussed at a meeting such as this, rather than in small isolated encounters, rumours or distortions of which may defeat the principal objective of putting New Zealand on the map as a fishing nation. The main emphasis of the meeting will be on an informal exchange of information and opinions. Please feel free to ask questions or comment on what Ministry staff and others have to say.

During the conference you will hear reports from scientists about the size of the resource and from both big and small members of the industry of problems and successes relating to skipjack fishing. In skipjack we have a substantial resource that can, and should, be harvested when it comes within range of New Zealand-based vessels.

Just how much we can or should take will again be the subject of comment and discussion. Skipjack is an international resource which is being exploited, and will be increasingly exploited, by many nations, including our island neighbours. Because of this New Zealand has indicated its support for a wide ranging study of the skipjack resource of the western Pacific. If the study proceeds, it will be supported by both the Indo-Pacific Fisheries Council (IPFC) and the South Pacific Commission (SPC); New Zealand is a member of both these bodies. I had hoped that Dr Robert Kearney, co-ordinator of this proposed skipjack assessment programme, would address us, but he is unable to attend and has sent his apologies. Nevertheless, the fact that he is organising the programme indicates the importance attached to the resource, not only by us, but by many others.

We are developing New Zealand's fisheries, but we do not necessarily have the ability "to go it alone". In other fields we readily accept the need to bring in overseas money and technology, for example, to develop our oil resources. To my mind the approach to the development of tuna fisheries need be no different, particularly as fish stocks represent a renewable resource which we can ultimately develop for our exclusive use. I want only one thing: to see New Zealanders, and New Zealand fishermen in particular, masters of their own destiny and users of their own resources.

It is not quite 10 years since I came to New Zealand and it is only 11 years since Fisheries Research Division was formed. Virtually nothing was known then about New Zealand's fish and absolutely nothing about the fisheries for them. We have made considerable progress in our field; the industry has made considerable progress in its field. If I am right and my staff are right, the progress in both fields during the next 10 years will substantially exceed the progress made in the past 10 years. At this meeting we are dealing with only *one* species and only *one* fishery. It is important to recognise the need to keep open minds, to listen and learn, and also to be aware that the principal objective of this meeting is to help towards mutual understanding and collective progress. It is on this basis that I have pleasure in opening the conference.

Skipjack as a Pacific Resource

D. Eggleston

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This paper presents fisheries aspects of skipjack biology and surveys present Pacific skipjack fisheries and current developments.

"Skipjack" is the internationally recognised name for *Katsuwonus pelamis*; "striped tuna" and "bonito" should not be used. This species occurs in almost all oceans and seas with surface sea temperatures over 18°C. In the Pacific skipjack occur from Japan south to southern Australia and New Zealand and across the Pacific in a broad, slightly narrowing band. In the eastern Pacific they occur from California to central Peru (Fig. 1).

The north-south extent of skipjack varies with season. Skipjack reach central New Zealand in our summer, but by mid winter most of the stock have retreated to

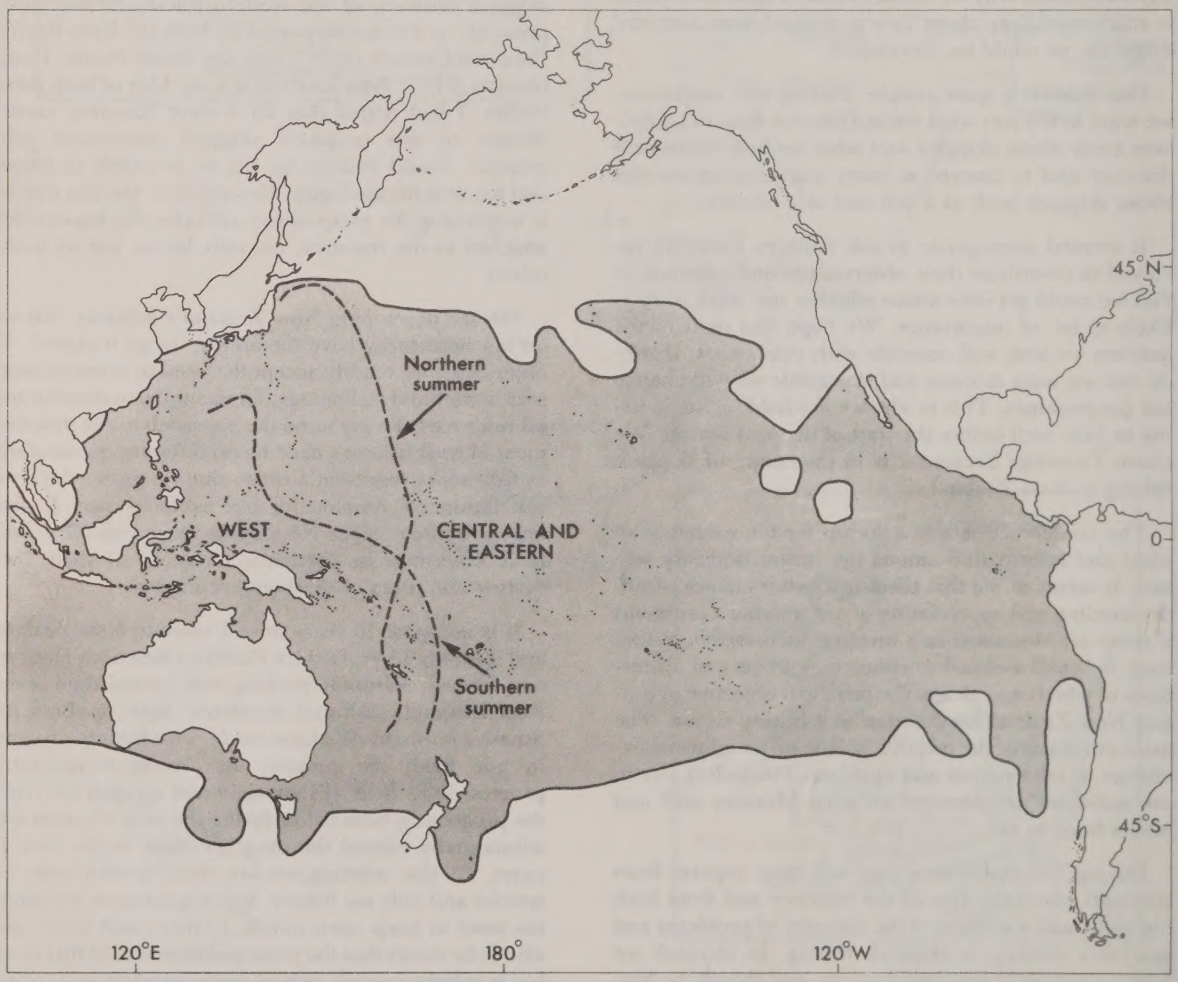

Fig. 1: Distribution of skipjack tuna in the Pacific Ocean. The boundary between western Pacific and central and eastern Pacific populations shown is after Fujino (1970).

north of the Kermadecs. [During discussion of this paper conference participants gave evidence that some skipjack occur around New Zealand throughout the year.] Thus, skipjack are seasonal at the north-south extremes of their range, but are present throughout the year in equatorial areas.

Skipjack are among the shallowest dwelling tunas; adult albacore, yellowfin, big-eye, and bluefin all inhabit deep water. The depth range of skipjack is set by their temperature and oxygen needs. Because of their high metabolic rate they require water with a high oxygen content; such water is generally found in the surface layers of the ocean. Skipjack usually occur in water with temperatures of 18 to 20°C and warmer, but their body temperature is often considerably (up to 15°C) higher than that of the water in which they swim. Because of this high body temperature it is thought that large skipjack are unable to live in those areas of the ocean where surface temperatures are very high and the oxygen content is too low in deeper, cooler layers. Smaller skipjack are not excluded from these areas, as they have less stringent oxygen and temperature tolerances. These differences can result in differing distributions of small and large skipjack, with larger fish in cooler water; that is, either deeper or closer to the extremes of the north-south range than smaller fish.

Skipjack tend to be concentrated in coastal areas, probably because these are the best feeding grounds. They also congregate in other areas where forage organisms are abundant, for example, in areas of upwelling or at current boundaries. Thus skipjack fisheries are generally within 50 miles of a land mass or island group. Obviously skipjack do cross open ocean areas, but they probably do this quite quickly as dispersed groups or subsurface schools rather than as surface schools vulnerable to fishing.

The seasonality and migrations of the fish stress the importance of further investigations on the interactions of stocks and migrations between different areas of the Pacific. Such a project is planned by the FAO international fisheries body, the IPFC, together with the SPC. If funds can be found for this project, it will provide many valuable and useful data on skipjack.

Skipjack feed on whatever is available. In most areas fish predominate in the diet. For much of the New Zealand season the schooling fish feed intensively on swarms of euphausiid crustaceans (tiny shrimp-like animals). Such fish may not be interested in live bait, but they are vulnerable to purse seining. When the fish are feeding on anchovies or other bait-fish around New Zealand they can be taken by pole and live-bait fishing.

Skipjack do not spawn around New Zealand. In the Pacific it is probable that skipjack spawn in mid-oceanic areas where surface temperatures are 22 to 30°C. In such areas spawning may occur at any time of year without a definite season. In the higher latitudes spawning occurs largely in the spring-summer period. The nearest spawning to New Zealand is probably around the Kermadec Islands, but significant amounts of spawning are unlikely south of New Hebrides, Fiji, Tonga, or Samoa (Fig. 1). Egg production ranges from 100 000 at each spawning for 40-cm fish to over 2 000 000 in large fish.

Skipjack growth rates vary in different parts of the Pacific, but until recently it was difficult to age the fish and thus derive age and growth rates. The recent discovery of daily otolith rings has facilitated accurate ageing. Only Hawaiian skipjack have been aged in this way and the data indicate sizes of 42, 72, and 82 cm at ages 1, 2, and 3. For eastern Pacific skipjack other techniques give most likely sizes of 37, 60, 76, and 87 cm for ages 1 to 4. Around Papua New Guinea the growth rate of fish over 45 cm is only 7 cm per year and fish over 65 cm do not occur.

The largest skipjack recorded was 106 cm long and weighed 32 kg. Fish over 18 kg are regularly taken around Tahiti. [In discussion participants gave evidence of 16-kg fish around New Zealand.] Even these large fish are probably under 10 years old.

Recent studies on skipjack blood chemistry suggest that skipjack in the Pacific Ocean are split into at least two groups: the western Pacific population, and the central and eastern Pacific population (Fujino 1970). The boundary between the two populations runs from east of Japan south to the New Hebrides (Fig. 1). The position of the boundary south of the New Hebrides is not clear, but Bay of Plenty fish are of the central and eastern group. There is also evidence that the central Pacific fish differ from those of the eastern Pacific. Further work on skipjack population boundaries is urgently required, as an understanding in this field is essential for resource management.

Conclusions to be drawn so far are that skipjack are abundant, widely distributed, migratory, seasonal, coastal tunas likely to fluctuate greatly in abundance. They are fast growing, voracious, highly fecund, and opportunistic spawners. To this should be added that they are good eating whether raw, cooked fresh, or canned.

This leads to the fishery aspects of the paper.

World tuna landings have almost doubled every decade since 1950 (Table 1). Growth has slackened in recent years because most of the large tunas are either overfished or at maximum yield levels. To supply market demand attention has turned to the smaller species. Skipjack is both the best quality small tuna and the major underfished tuna resource.

TABLE 1: World tuna landings (t)

Year	All tunas	Skipjack
1950	400 000	?*
1960	800 000	220 000
1970	1 500 000	370 000
1974	1 875 000	590 000

* ? indicates quantity unknown

The potential yield of skipjack is not known. One million tonnes (t) has been mentioned (Kawasaki 1972), but there is no reliable estimate available. The 1974 world landing of skipjack was 590 000 t; this is up from 370 000 t in 1970, 300 000 t in 1965, and 220 000 t in 1960 (Table 1). As yet there is no evidence of overfishing or adverse effects of fishing in any area. This has led to optimistic views on possible increases in skipjack landings. Nonetheless there are large fluctuations in availability of skipjack from year to year in all documented skipjack fisheries. Between 1960 and 1973 landings in the eastern Pacific have ranged from 30 000 to 120 000 t, the Japanese coastal fishery landings fluctuated between 78 000 and 201 000 t, and the Hawaii fishery from 3300 to 7400 t. The Papua New Guinea fishery has ranged from 17 000 t to 42 000 t since 1971.

Skipjack present attractive development prospects, not only to New Zealand, but throughout the Pacific. Almost all the Pacific island nations and territories are looking to this species as a means of increasing fish landings and export earnings. Japan, Russia, and the United States are planning to expand skipjack fisheries in the Pacific. New Zealand and Australia are also developing their fisheries (Fig. 2).

Skipjack landings in the Pacific are listed in Table 2. These data relate to 1973, 1974, or 1975, depending on most recently available figures. In some cases estimates have been made, as other data are not available. Because of the large year to year fluctuations these totals must be considered only as indicative of the scale of each fishery rather than as average yearly landings in each fishery. The data also indicate the wide range of countries fishing the skipjack resource.

In the western Pacific the 1974 landings for the area north of the Philippines exceeded 130 000 t; landings between the Philippines and northern Australia were over 215 000 t. The combined New Zealand and Australian landing for the 1974-75 season was much smaller in comparison (about 3200 t). The corresponding figure for 1975-76 was about 5500 t. Almost half of the 800 000-t catch of all tunas from the western Pacific in 1974 consisted of skipjack.

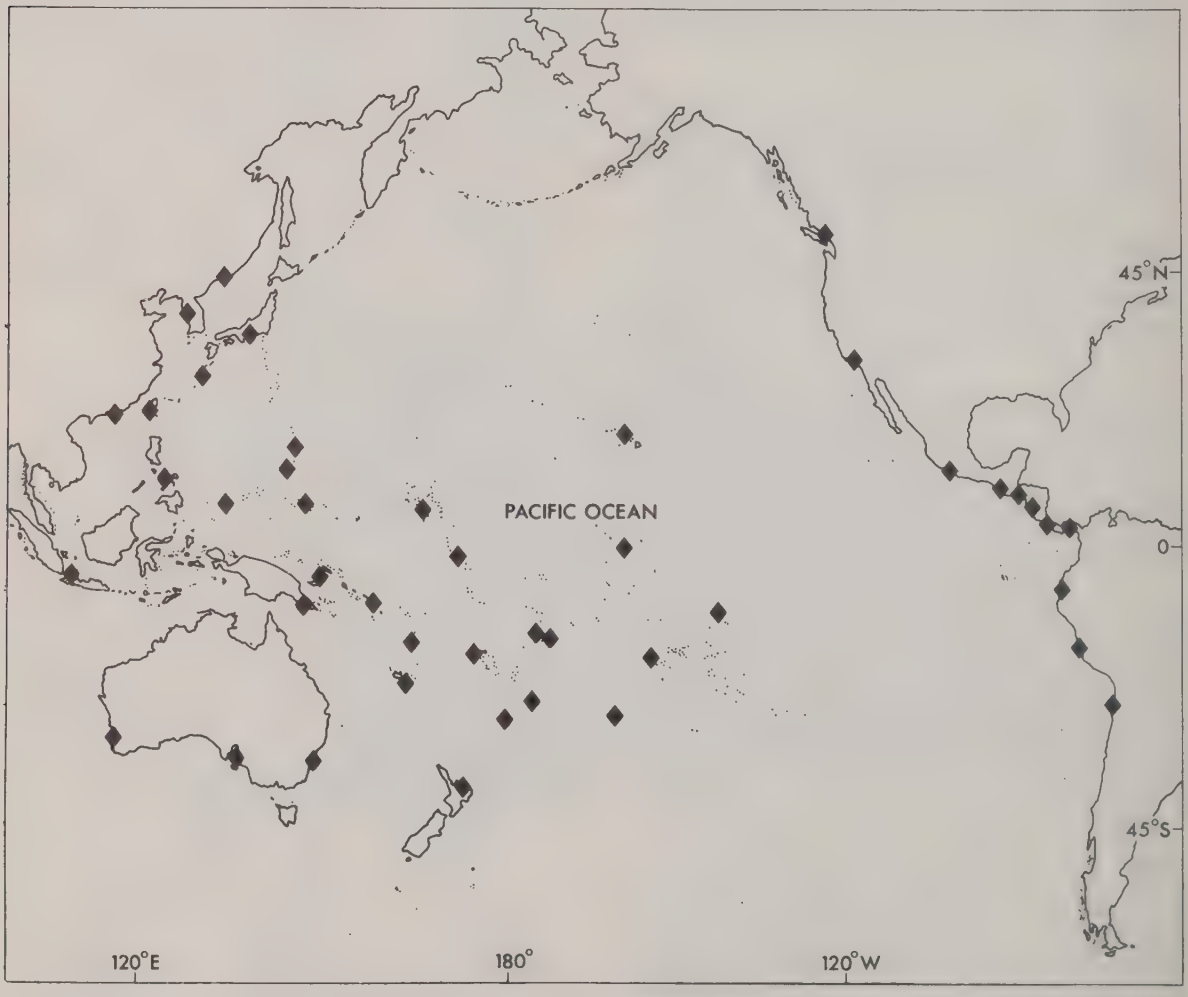

Fig. 2: Countries and territories developing or expanding skipjack fisheries in the Pacific.

TABLE 2: Pacific skipjack landings (t). (Degree of accuracy varies with information available.)

Japan	300 000
U.S.A.	50 000
Papua New Guinea	40 000
Philippines	20 000
Indonesia	20 000
Solomon Islands	10 000
Ecuador	9 000
New Hebrides	7 000
Palau	6 000
Hawaii	5 000
New Zealand	5 000
Peru	4 000
Korea	4 000
Canada	3 000
Mexico	2 500
French Polynesia	1 000
Australia	500
Fiji	100
Cook Islands	100
New Caledonia	100
Gilbert Islands	50
American Samoa	50
Western Samoa	30
Tonga	10
Guam	10
Taiwan	?*
U.S.S.R.	?
Chile	?
Pacific total about 450 000	

* ? indicates quantity unknown

It is also important to recognise the significance of skipjack to the island nations. In these smaller countries skipjack comprise up to 90% of the total landings and are the only major source of potential expansion in fisheries for both increased local consumption and import replacement or export earnings.

Present Law of the Sea drafts call for international management of highly migratory species, including skipjack. Because of the wide range of the species and the lack of knowledge of the migrations, populations, and potential interactions between fisheries and the rapidly developing nature of these fisheries, it is obviously important to set up co-ordinated research programmes over the range of the species. Research proposals such as the IPFC/SPC Skipjack Assessment Programme, which has a high component of tagging and fishing trials as well as bait-fish assessment, deserve support. Urgent international attention should also be given to developing appropriate bodies responsible for co-ordination of research and future management of the skipjack resource.

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Biological Data on Skipjack in New Zealand Waters, 1973-76

C. M. Vooren

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Length-frequency Distributions

Data on the 1973-74 and 1974-75 seasons were collected from catches taken by the purse seiner *Paramount* in the Bay of Plenty in January to March 1974 (15 catches sampled, 678 fish measured) and January to February 1975 (19 catches sampled, 1020 fish measured).

The 1975-76 season started in November 1975 off Reef Point. The area off the north-east coast of the North Island between North Cape and Cape Runaway was fished from December 1975 until the beginning of March 1976. A random sample of at least 100 fish was measured at sea from each catch by each of the three large Californian purse seiners operating at the time (137 catches sampled, 23 249 fish measured). Catches made in January and February 1976 in the Bay of Plenty by the two small New Zealand purse seiners were sampled ashore (893 fish measured). The lengths measured were fork lengths, rounded to the nearest whole centimetre. [Details of the areas fished and of the vessels fishing are given in G. Habib's paper on page 40.]

During the 1975-76 season the Californian vessels usually worked close together. The length-frequency distributions of their catches were similar and except for a gradual shift in modal lengths there were no great changes in length composition from January to March 1976. All the length measurements taken on these vessels could therefore be grouped by intervals of about 2 weeks to provide a full record of the length composition of the catches throughout the season (Fig. 1). No fish were measured in November 1975 off Reef Point, but measurements of trolled fish indicated that the schools consisted mostly of fish 50 to 60 cm in length, with a modal length of 55 to 56 cm. The catches in December 1975 off the north-east coast were dominated by fish of 50 to 60 cm, with a modal length of 56 to 58 cm (Fig. 2, group D). This mode disappeared almost completely from the catches in the following months, and from January onwards the main mode occurred consistently at 44 to 47 cm (Fig. 2, group A). Analysis of the length-frequency distributions by means of probability paper (Cassie 1950) confirmed the existence of minor modes at 37 to 41 cm (Fig. 2, group B, January to March) and at 35 to 36 cm (Fig. 2, group C, March only).

Modes A and B shifted during the season to higher values; both modal lengths were 3.5 cm greater in early March than the corresponding lengths at the beginning of January. This increase in modal lengths over 2 months probably reflects growth of the fish and corresponds to an increase in body weight of 400 to 500 g.

A variety of growth curves of skipjack in the eastern Pacific Ocean and off Japan can be found in the literature (summarised by Joseph and Calkins 1969). The slope of the band covering these published curves indicates that fish at lengths of between 30 and 60 cm grow 1.5 to 2.0 cm per month (Fig. 3). This growth rate is similar to the 3.5 cm in 2 months recorded during the present study. From these values it follows that the fish in modal groups B and C were, respectively, 3 and 6 months younger, and those in modal group D were 6 months older, than the fish in modal group A. The modal length of the fish in January to February 1975 (Fig. 2, group E, and Fig. 4) lies roughly half way between modes D and A observed in 1976. These data lead to the conclusion that the modal groups of skipjack found off the north-east coast of New Zealand differ in age by 3, or multiples of 3, months. Thus the skipjack schools found off the north-east coast of New Zealand during a single fishing season consist of fish belonging to several distinct cohorts. (A cohort is defined here as all the fish spawned at or near a particular time and moving through the fishery as a distinct group.) The data from the three seasons indicate that as a rule one cohort dominates strongly in the catches of large purse seiners during most of the season.

There is no information on the growth pattern of the fish before their arrival off the New Zealand coast; so their age is unknown. From the published skipjack growth curves it appears that the possible age range of the skipjack in the fishery is between 1 year for the smallest fish (group C) and 2.5 years for the largest fish (group D, see Fig. 3). Within this age range, if growth takes place throughout the year at the rate of 1.75 cm per month, which was measured in January to March 1976, the annual growth rate is 21 cm.

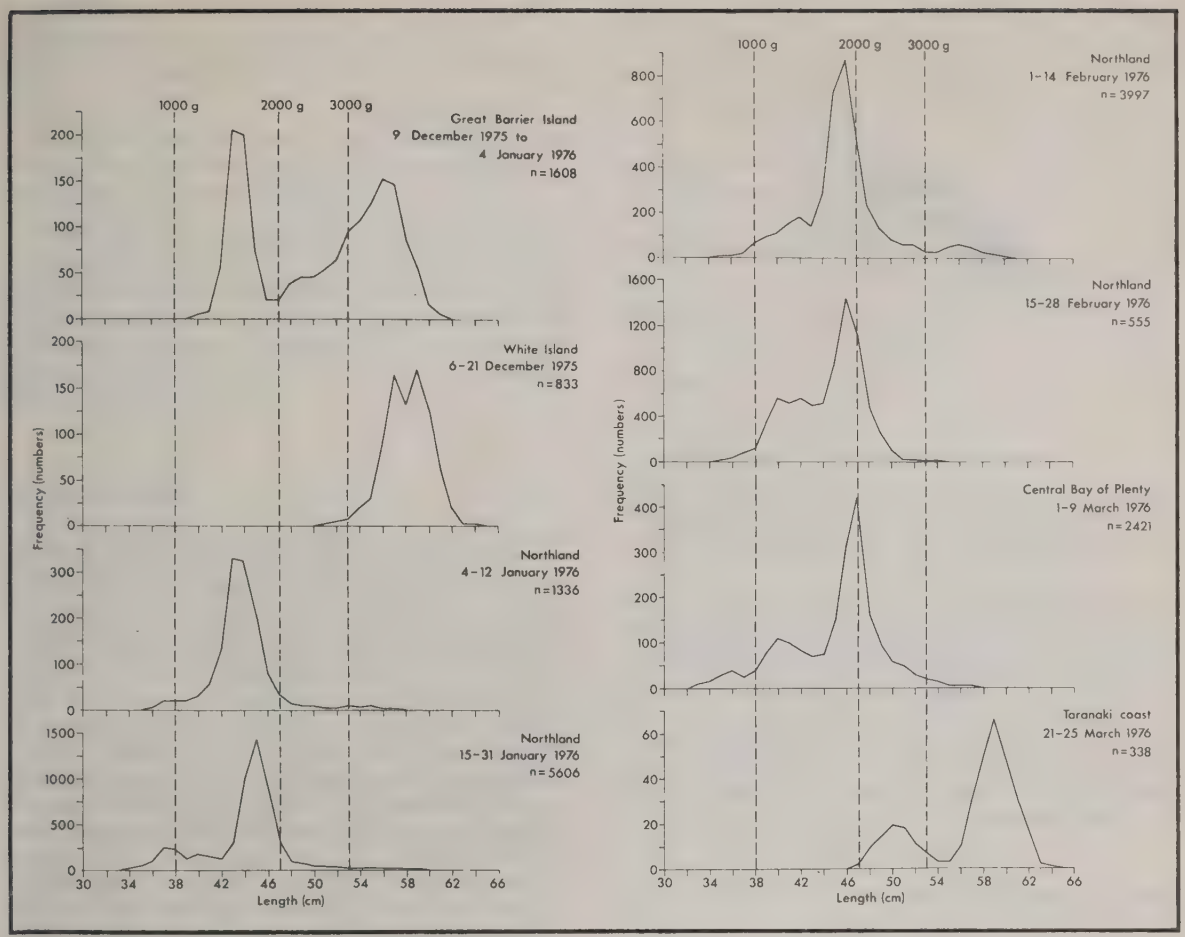

Fig. 1: Length-frequency distributions of skipjack tuna in catches made by three Californian purse seiners off New Zealand, December 1975 to March 1976.

It follows from a comparison of the length-frequency distributions of the three consecutive seasons that few, if any, fish of cohorts that contribute large proportions to the catches during a given season occur in the catches of previous and following seasons. For example, the modal length of the cohort that appeared as group D in February 1976 would have been about 35 cm in February 1975, and the length-frequency distribution for that month shows very few fish of such a size. As another example, the cohort that dominated the catches in January to February 1975 would have had a modal length of about 70 cm in the same months of 1976, and fish of this size were not caught in the 1975-76 season (Figs. 1 and 4).

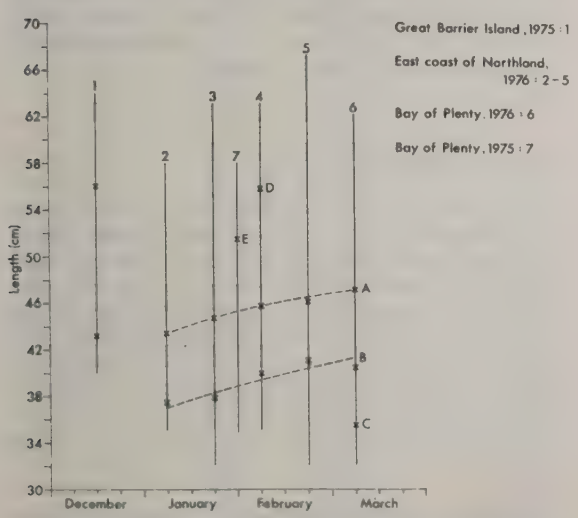

Fig. 2: Length ranges and modal lengths A-D (indicated by X) of skipjack tuna in purse seine catches off New Zealand, 1975-76.

In 1975-76 modal groups B and D were important components of the catches by the New Zealand vessels (Fig. 5). Thus the modal groups that formed minor peaks in the length-frequency distributions of the catches by the large foreign vessels were much more obvious in the catches by the smaller New Zealand vessels. The reason for this difference between the catches by the two types of boats could be that the less abundant size classes form smaller schools than the dominant modal groups: The New Zealand boats fished much smaller schools than the foreign boats and were perhaps selectively fishing for the less abundant size classes.

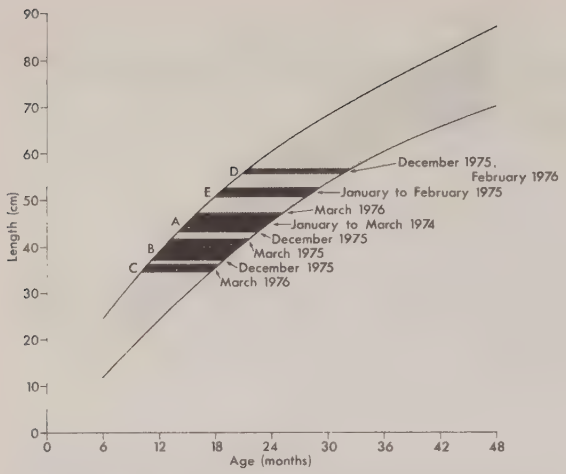

Fig. 3: Modal lengths A-D of skipjack tuna in purse seine catches off New Zealand, 1975-76, superimposed on the band covering growth curves of skipjack tuna off Japan and in the eastern Pacific Ocean listed by Joseph and Calkins (1969).

Some fishing took place off the Taranaki coast near the end of the season. The length-frequency distribution recorded there was entirely different from that found earlier off the north-east coast (Fig. 1). The first of the two modes off Taranaki did not fit in with any of the modes observed earlier in the season. The origin and age structure of the fish off the west coast of the North Island may be different from those of the fish found off the north-east coast.

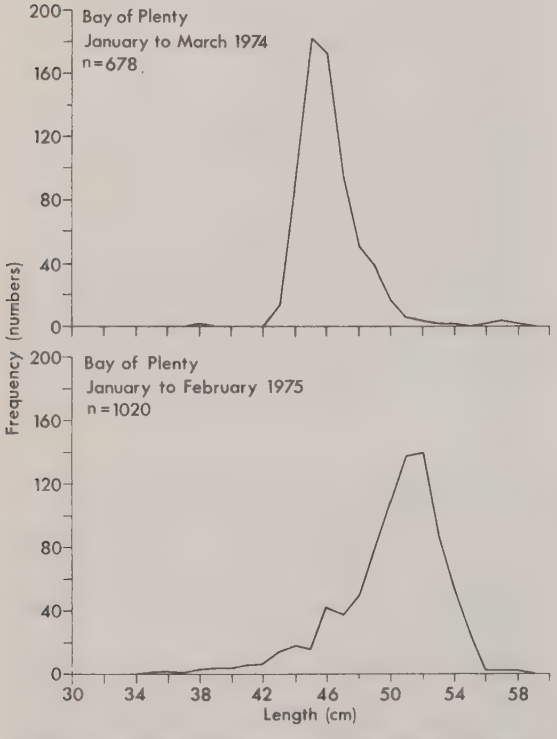

Fig. 4: Length-frequency distributions of skipjack tuna caught by the purse seiner *Paramount* off New Zealand in 1974 and 1975.

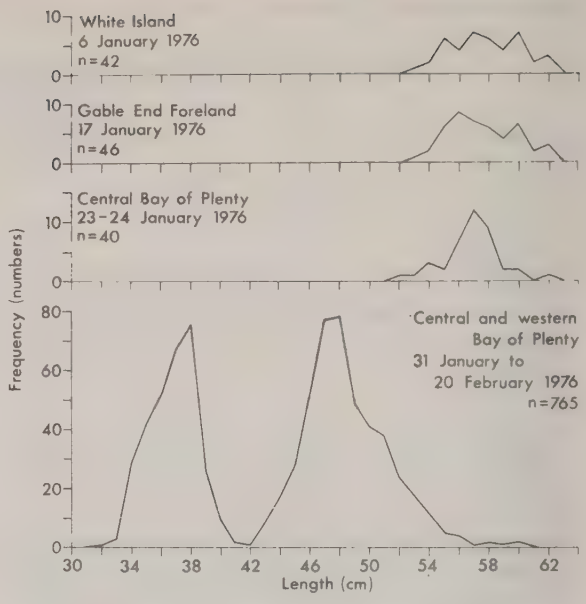

Fig. 5: Length-frequency distributions of skipjack tuna caught by two New Zealand purse seiners in January to February 1976.

The New Zealand skipjack catches are similar in length range to the catches in the Japanese fishery, which also show a single major mode between 40 and 50 cm (Kawasaki *in* Waldron 1963). Off Hawaii the catches show several main modes, one between 40 and 50 cm and others at larger sizes (Brock 1954). In the eastern Pacific the main modes occur generally at lengths greater than 50 cm (Waldron 1963). In the Bismarck Sea in 1972 skipjack were mostly between 50 and 60 cm long (Lewis, Smith, and Kearney 1974). Thus the length composition of the New Zealand skipjack occurs at the lower end of the size range found in other skipjack fisheries in and around the Pacific Ocean. It can therefore be concluded that the skipjack in the New Zealand fishery are young recruits which belong to cohorts that have not been subjected to fishing elsewhere in their geographic range.

Length-weight Relationship

Total body weights including the stomach contents (to the nearest 25 g) and fork lengths (to the nearest millimetre) were measured for 2 skipjack samples of 50 fish each, collected from purse seine catches in the Bay of Plenty on 6 March and 8 March 1976. In one sample the stomachs were empty in all but one fish. In the other sample the stomachs contained only small amounts of food; the contents of the fullest stomach amounted to only 2% of the total body weight. Thus the inclusion of the stomach contents had little effect on the overall body weight.

A linear regression equation was fitted by the least squares method to the logarithms of weight (dependent variable) and length of each fish sampled.

The equation took the form:

$\log_e W = -11.99 + 3.19 \log_e L$

where W = total body weight (g) and L = fork length (mm).

This curve fitted the data well and was similar to the curve derived by Chatwin (1959) for skipjack in the eastern Pacific Ocean (Fig. 6).

The weights predicted for given lengths by the equation are listed in Table 1. In combination with the length-frequency distributions this table shows that the approximate modal weights of skipjack during the 1975-76 season were 1520 g and 3500 to 3900 g in December and 1530 g in January; the main mode shifted to 2030 g in March.

Gonad Condition

The gonads of the fish in the two samples discussed in the previous section were examined and weighed. At body lengths of between 35 and 44 cm the gonads were thread-like and weighed mostly less than 1 g. At body lengths of between 44 and 54 cm the gonads were thread or ribbon shaped and weighed up to 12.8 g. The sexes could not be distinguished macroscopically. The gonad weights of these larger fish formed 2 groups: a cluster of 40 points below 2 g, and a more diffuse group of 37 points centred around 5 g (Fig. 7). Among the fish of 44 to 54 cm fork length those with gonads of less than 2 g in weight may be males and those with heavier

TABLE 1: Expected weights of skipjack of given lengths, derived from the equation $\log_e W = -11.99 + 3.19 \log_e L$

Length (mm)	Weight (g)
300	485.39
310	538.84
320	596.19
330	657.61
340	723.22
350	793.20
360	867.69
370	946.84
380	1 030.80
390	1 119.74
400	1 213.81
410	1 313.16
420	1 417.95
430	1 528.34
440	1 644.48
450	1 766.55
460	1 894.69
470	2 029.06
480	2 169.83
490	2 317.17
500	2 471.22
510	2 632.16
520	2 800.15
530	2 975.35
540	3 157.93
550	3 348.05
560	3 545.87
570	3 751.58
580	3 965.33
590	4 187.29
600	4 417.63
610	4 656.50
620	4 904.10
630	5 160.58
640	5 426.13
650	5 700.91
660	5 985.07
670	6 278.80
680	6 582.27
690	6 895.66
700	7 219.14

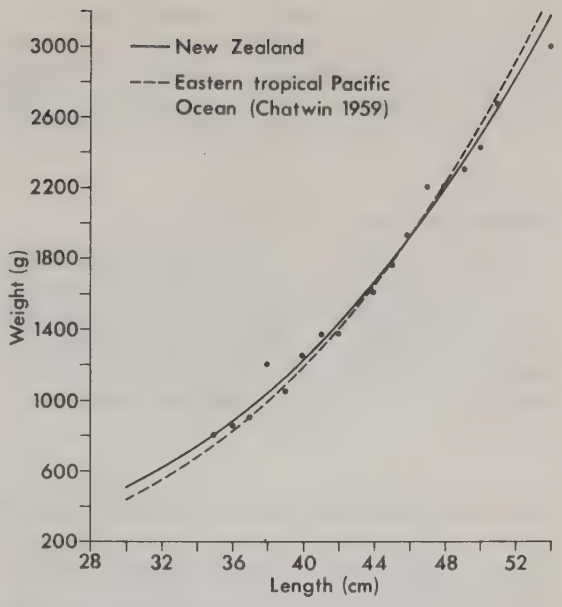

Fig. 6: Length-weight relationship of skipjack tuna caught off New Zealand by purse seine in March 1976, showing data points (mean weights of centimetre groups) and the fitted curve. The curve published by Chatwin (1959) for skipjack tuna from the eastern Pacific Ocean is also shown.

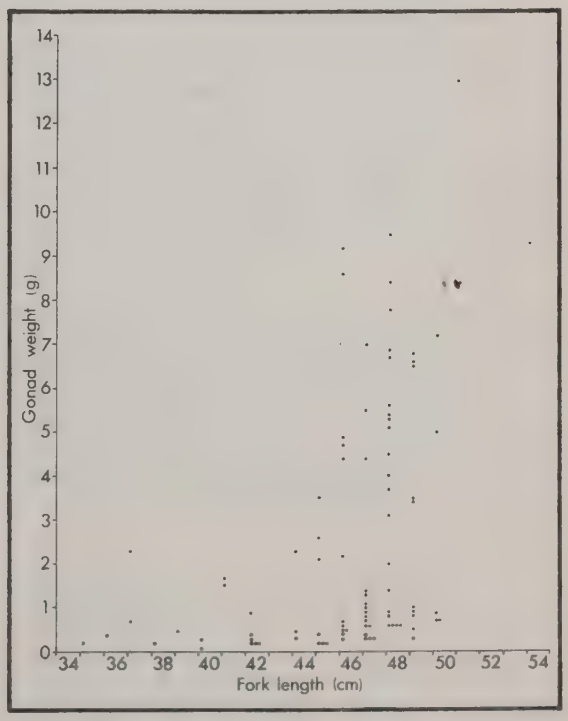

Fig. 7: Gonad weight plotted against body length of skipjack tuna caught off New Zealand by purse seine in March 1976.

gonads females. This possibility remains to be investigated histologically. The small size of the gonads and the lack of sexual difference at the macroscopic level indicate that the fish were "immature" according to the definition given by Marr (1948).

Food and Feeding

Stomach contents were investigated in the two samples. From these samples and from occasional observations throughout the season it was obvious that the euphausiid *Nyctiphanes australis* was the main food item taken by the skipjack schools that were fished by the purse seiners. In fact no other food was found in any of the stomachs examined. Roberts (1972) found a similar situation in skipjack caught by trolling off the north-east coast of New Zealand in November 1971, though fish made up a small proportion of the stomach contents. York (1969), however, found that off the east coast of the North Island fish (chiefly *Engraulis australis*) were dominant in the diet of skipjack caught by trolling and gill netting in 1965 and 1966. Both regional and behavioural factors could account for these differences in diet. Skipjack may form large schools when they feed on *Nyctiphanes* and so this food item would be dominant in stomachs of fish caught by purse seine. The fact that skipjack can be caught by trolling indicates that they will take food other than *Nyctiphanes* when it is available.

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A Review of Management Policies and Future Objectives

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Current Management Policies

The four methods of catching skipjack tuna which have been used in New Zealand waters are gill netting, trolling, pole and line fishing (poling), and purse seining. The first three are more suited to smaller vessels, though on the wider world scene poling is a proven offshore fishing method for large vessels. Purse seining by vessels capable of catching and stowing large catches quickly is particularly suitable for the seasonal skipjack fishery in New Zealand.

Each of the vessels to be used must be registered in accordance with the Fisheries Act 1908 and its Amendments and Regulations. The vessels must be manned, surveyed, and equipped to standards set by legislation administered by other Government agencies such as Ministry of Transport and Post Office.

The Minister of Agriculture and Fisheries can authorise New Zealanders or New Zealand companies to charter vessels and crews from overseas for experimental purposes. Such vessels must be registered as New Zealand fishing vessels during the charter period and must be operated in accordance with the provisions and statutes applying to New Zealand fishing vessels.

Before beginning to fish fishermen require permits, and there is also an obligation to complete and return to the Ministry of Agriculture and Fisheries accurate fishing returns which give details of catches and catching locations and the gear used to make the catches. The provision of this information, often considered by fishermen an unnecessary chore, is vital for fisheries research and management purposes.

There are two further conditions to which charter vessels must conform during fishing operations. First, staff of the Ministry are to have access to the catch, and, second, catch and effort data are required in much greater detail than is normally required on catch return forms.

Other controls relating to skipjack tuna fishing are few. There is no size limit applied to this species. There are no restrictions on any of the methods of catching except, in broad terms, on purse seining. Mesh size regulations are not restricting because the mesh of purse seine nets usually exceeds the minimum stated in the regulations for the species likely to be taken by this method. With the exception of small numbers of overwintering fish, the skipjack form a migratory stock which passes through New Zealand waters seasonally and so there is no restraint on maximum catches.

If skipjack and other species taken by purse seining are to be marketed in the United States, the nets used must be designed to permit the escape of marine mammals such as porpoises. This usually entails fitting a Medina porpoise panel in these nets. This is a trading requirement and all companies purse seining for skipjack in New Zealand waters have been advised of this. Although porpoises are not yet specifically protected, it is expected that all marine mammals will eventually be fully protected within New Zealand fisheries waters, at which time all fishermen will have to ensure that these animals are not taken or killed during fishing.

The taking of swordfish by purse seine is prohibited. The use of explosives or explosive devices to catch or destroy fish is not usually allowed. However, permission can be obtained to use appropriate devices such as "cherry bombs" where these are used to hold the fish until pursing is completed.

The New Zealand fishing fleet is encouraged to expand to enable it to increase the skipjack catch. This expansion may include all the methods mentioned earlier, but it appears that purse seining is the most appropriate method for harvesting quickly the migratory resource when it "schools up" close to our shores. To increase the efficiency of seiners in locating schools of fish, their operations should be supported by spotter aircraft.

The Law of the Sea Conference and Future Objectives

At present our fisheries waters consist of a 3-mile territorial sea and outside that a 9-mile fisheries zone, which gives a 12-mile band from the appropriate baseline. Outside this band anyone may fish. Soon we expect to be able to control the exploitation of the

resources of a zone a further 188 miles outside the present fisheries zone. It is expected that, either through the Law of the Sea Conference discussions or the development of customary law, the width of the territorial sea will be increased to 12 miles, outside which there will be a 188-mile exclusive economic zone. The fisheries resources within territorial seas and economic zones off coastal states will be under the control of the coastal states. In the New Zealand situation these waters would be New Zealand fisheries waters.

We expect to achieve an exclusive economic zone through the drawing up of a multilateral Law of the Sea Treaty which will be formally ratified. If this does not occur, the same objective could probably be achieved by unilateral action, which is beginning to have a basis of acceptance within international law. If unilateral action is taken, I would expect the provisions of any further revised edition of the Single Negotiating Text (of the Law of the Sea Conference) to form the guidelines followed by New Zealand. In general this means that the coastal state would have the power to determine the total allowable catch within the exclusive economic zone. The proportion of that catch which our fleet could take would be reserved for it. Any surplus would be made available to other countries, but under very strict licensing procedures.

For skipjack and other migratory species it would be necessary to establish an appropriate commission to ensure management of the resource inside our exclusive economic zone, and of the total stock throughout its range, and so control the rate of exploitation. This commission would probably be a regional one consisting of all countries that fish the stock or stocks fished by New Zealanders. Such a commission should have scientific advice, probably from an expert committee, to assist it to make recommendations to member countries. These could include aspects such as minimum size limits, maximum catches in various zones, limitation of effort (and this may be based on selected methods or on all methods), and closed areas. It is expected that quotas for areas will be the greatest problem.

In a skipjack fishery off our shores it should be possible to use the four fishing methods mentioned earlier when the fish are within easy reach of our fleet. We could also use purse seiners and pole vessels off shore.

If New Zealand does wish to develop an off-shore fishery for skipjack, it should be done now. This would establish our presence and enable our voice to be heard through commissions. Some areas now being fished by the larger purse seiners are already covered by established international commissions, but other potential fisheries exist where appropriate commissions will need to be established. If, in the longer term, it is considered that the retention of such off-shore rights is not desirable, it will be easy to retract, but I consider that unless off-shore expansion takes place now, the opportunity will be lost. If purse seining and poling are to develop significantly in New Zealand, we must consider operating over more of the range of the migratory species and not just in our territorial sea or the exclusive economic zone.

Future Management

Within its economic zone New Zealand must be prepared, should it prove necessary, to limit the quantity of skipjack which can be taken. I hope this will not prove necessary. However if it does, the provisions of the controlled fisheries legislation, which it is hoped will have been enacted, could be used for this purpose. New Zealand may have to enact a legislative framework to ensure that any recommendations made by an international commission concerning stocks of fish can be implemented.

We have a skipjack resource, at least on a seasonal basis; so all we need is the legislative framework to manage this stock to New Zealand's best advantage consistent with the development of our national fisheries fleet. This fleet should be developed to enable it to catch the maximum quantity of skipjack, without damaging the resource, to feed into the world's marketing system.

The Australian Tuna Fishery

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The Australian tuna fishery began shortly after the Second World War. It was modest initially; only southern bluefin tuna were caught by troll boats during summer. The fish were canned in plants already established to handle Australian salmon (kahawai).

Gradually the emphasis shifted from trolling to pole and line fishing with live bait-fish, and from part-time tuna fishing to the use of specially designed pole and line vessels. Finally in 1974-75 purse seining was introduced.

The fishery began off New South Wales, then developed off South Australia and finally off Western Australia. A long-line fishery, mainly operated by the Japanese, was established on the Australian southern bluefin stocks in 1952. This fishery reached full development in 1959, when about 50 000 t of tuna were being taken annually. The Australian fishery did not reach full development until 1968, since when landings have been about 9000 t per year.

Southern bluefin spawn in the Indian Ocean south of Java. They appear off Western Australia as 2-year-olds in May and June, and off eastern Australia during September to January. These older fish move to waters off South Australia during January to April. They begin moving out of the surface fishery at 4 to 5 years of age and enter the off-shore long-line fishery, gradually spreading along the northern fringe of the Antarctic from 180° W to about one-third of the way across the Atlantic. They appear to mature at 7 years. The life span is probably about 20 years and maximum length about 190 cm. A wealth of information is available on this stock as a result of research by Australian and Japanese scientists.

The same cannot be said for the skipjack off Australia. This species was shown to be plentiful in Australian waters by CSIRO scientists in the mid 1950s, but was ignored as a resource until the 1973-74 season, when about 1500 t were taken by three purse seiners. These vessels, as well as some of the pole and line boats, have continued to catch skipjack. During the 1974-75 season, 2084 t were caught, 1875 t by purse seiners and 209 t by pole and line boats. Most of the fish are 45 to 55 cm in length, but last season some fish up to 80 cm were caught.

Because there is overwhelming evidence that the southern bluefin is fully exploited further growth of the Australian tuna industry must depend on catching skipjack. There are, however, a number of problems. On the scientific side, it is crucial to establish the identity of the stock or stocks. Preliminary data suggest that the fish taken off New South Wales are of the western Pacific stock and are therefore different from New Zealand skipjack. [See D. Eggleston's paper on page 8.]

On the commercial side the seasonal distribution and abundance need to be investigated, as fishermen often have difficulty locating schools of fish.

When and if these problems are solved, a marketing problem will almost certainly develop, because the domestic market could not absorb much more than 2000 to 3000 t at current rates of consumption. This, in the face of a resource that gives indications of yielding about 50 000 t annually, points to the need to establish overseas market outlets for skipjack tuna.

Skipjack Fishing from Small Vessels

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In 1965 Japanese technicians were brought to New Zealand to demonstrate, among other fishing techniques, tuna long-lining, gill netting, and purse seining. After these demonstrations the Fisheries Management Division, which was then part of the Marine Department, and the Fishing Industry Board began jointly investigating the possibilities of trolling and gill netting for albacore and skipjack. This programme was based at Gisborne and continued until 1967.

Acoustic experiments were carried out from Whakatane between December 1968 and May 1969 in which tuna feeding sounds were recorded and gill nets used. As a result of this work Fisheries Management Division staff entered into a fishing venture with Whakatane small-boat fishermen during the 1969-70 and 1970-71 summer seasons.

Gill Netting

In the 1965 Japanese fishing demonstrations a large hydraulic reel capable of holding five gill nets each 146 m long and 21 m deep was used to set nets from the fishing vessel *Trade Wind.* No skipjack were caught for the following reasons:

1. The motor on the reel was very noisy and kept fish away from the vessel.
2. The Japanese method of "passive fishing", where nets were set and left for long periods in areas where skipjack were expected to school, was unsuited to New Zealand conditions.
3. The nets often fouled *Trade Wind's* propeller, which hampered fishing operations.
4. Setting five nets from one reel took 15 minutes, which was too slow for this method to be effective in catching skipjack.

Throughout the Gisborne project nets were set by hand, which reduced the noise of setting from a large reel. Catch rates improved to 11.5 fish per hour. Other variations such as anchoring the nets and setting them at night were unsuccessful.

In the Whakatane joint fishing venture one net at a time was set at speeds up to 10 knots, which resulted in most sets being completed in less than 60 seconds. By this method 1380 kg of skipjack were caught from *Trade Wind* at a rate of 690 kg per hour. Another vessel, *Takapu* (9.75 m long), landed 9072 kg in two 10-day periods, and from February to April the Whakatane fleet landed 108 900 kg of skipjack.

Pole Fishing

In the early 1960s J. Wattie Canneries Ltd of Gisborne converted the first New Zealand vessel to pole fishing. This vessel, *Olwyn,* converted under the direction of an American, Mr Phillips, and skippered by "Blondie" Madsen, surveyed southern bluefin stocks in Fiordland in 1964, but had little success. In 1970 I did some pole fishing in the Bay of Plenty from the vessel *Stranger.* At about this time *Pirimai* was fitted out for pole fishing and in her first 3 months of operation she landed 60 t of tuna (see Killion 1971). She had further success during the 1971-72 season, landing 154 t. In 1971 a number of fishermen on small boats began pole fishing for tuna in the Bay of Plenty. Many of these fishermen in fact gained some of their early poling experience on *Pirimai.* In recent seasons pole fishing has become the most consistent and profitable method of tuna fishing for small vessels.

Trolling

The first significant catch of skipjack by trolling was made in April 1970, when 1820 kg were taken on *Stranger.* This effort was preceded by experiments with various coloured lures trolled at varying speeds in different weather conditions. It was found that in overcast conditions the most successful lure combined 80% of dark and 20% of light colours. The opposite held in sunny conditions. Light-coloured lures were also more effective in blue oceanic water, and dark lures in green in-shore water. The most effective trolling speeds were from 9 to 12 knots. In 1970 skipjack were caught as early as 4 a.m., as late as midnight, and even several miles up the Whakatane River, where the surface salinity was 11.7‰.

Long-lining

After studying the Australian method of long-lining for sharks on *Cindy-Hardy,* I decided to try catching tuna with modified shark long-lines. These were 300 fathoms long with 5-fathom buoy lines at 30-fathom intervals and 2-fathom snoods at 5-fathom intervals; they were fitted with Japanese albacore tuna hooks. These lines were used near White Island in the Bay of Plenty for limited periods in 1970 and caught albacore at a rate of 6 fish for each 100 hooks, but no skipjack were caught.

Purse Seining

The history of purse seining for tuna in New Zealand is reviewed in these proceedings by D. Eggleston in his paper on the *Paramount* project [page 31]. I would like to add here that Sanford's *Lindberg* joined the fishing in 1975 and she and *Marine Countess* constitute New Zealand's present purse seine fleet. Both these vessels continue to increase their catches per unit of effort as they gain experience in the fishery.

Aerial Spotting Assistance

W. Christopherson of Tauranga pioneered aerial tuna spotting in New Zealand when flying for the Tauranga-based Union Fish and Ice Company during the early 1960s. I carried out some spotting in Cook Strait and Taranaki Bight in 1963. However, it was not until 1968 that this method was used to assist small vessels in skipjack fishing operations. At this time I hired Graham Bell of Whakatane to make spotting flights over the Bay of Plenty and we provided a number of vessels with fishing information by radio. Such information has been provided from this source ever since.

Conclusions

I have stated that pole fishing is probably the most profitable method of catching skipjack from small vessels, but I would like to point out that other methods will also yield good catches in particular situations. For example, gill netting is particularly suited to situations where large numbers of skipjack are travelling at speed through an area. From my observations of echograms I feel that bottom gill nets could also yield reasonable catches at times when skipjack are feeding near the bottom. Since the commercial viability of fishing for skipjack from small vessels has been well established, this aspect of the fishery should be actively encouraged.

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Pirimai and Live-bait Pole Fishing

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During the 1971-72 summer, live-bait pole fishing for skipjack was carried out from the m.v. *Pirimai*, a 28-m wooden trawler and long-liner modified for this method. A daily fishing log was kept by Mr A Campbell, fishing master on *Pirimai*, for the period 1 January 1972 to 17 April 1972. These records are summarised below. Data recorded were: date, area fished, species caught, number and estimated total weight of each species, and, occasionally, sea surface temperature.

Experience from the previous tuna season and the early part of the 1971-72 season had clearly shown that it was not profitable to change fishing areas frequently. A decision was made to fish for skipjack in the Bay of Plenty from January to May.

During the 108-day period in which fishing was carried out about 154 t of tuna, including 140 t of skipjack, were landed at an average catch rate of 1.43 t per day. Only 42 of the 108 days (that is, 38% of the fishing season) were spent on the tuna grounds, so that the average catch per fishing day was 3.67 t. A large proportion of the 42 fishing days was spent searching for suitable schools; on 19 days (45% of days fished) less than 1 t of skipjack was caught (Fig. 1).

The cumulative percentage of catch is shown in Fig. 2a; 50% of the catch was landed by 17 February and 75% of the catch by 25 February. About half of the total landings were caught in the first 22 days of February. The fishing pattern consisted of initial searching periods with scattered catches followed by short bursts of activity as good schools were located. This was usually followed by a long period of apparent inactivity occupied with unloading, rebaiting, and more searching.

The first three periods of good fishing — 6 to 12 January, 18 to 19 January, and 31 January to 2 February — were near Mercury and The Aldermen Islands in the western Bay of Plenty. However, few fish were caught there when the vessel returned on 11 February, and searching moved to the eastern Bay of Plenty. Here, between White and Whale Islands, excellent fishing prevailed and almost 56 t of skipjack were poled in 7 fishing days. The vessel returned to the same area after a considerable (17-day) break for unloading, repairs, and rebaiting, but only 2.5 t were landed in a further 7 days of fishing. After extensive searching, schooling fish were again located between Mercury and The Aldermen Islands from 21 to 28 March. However, only one more large catch (10.4 t) was made before tuna fishing ended on 17 April.

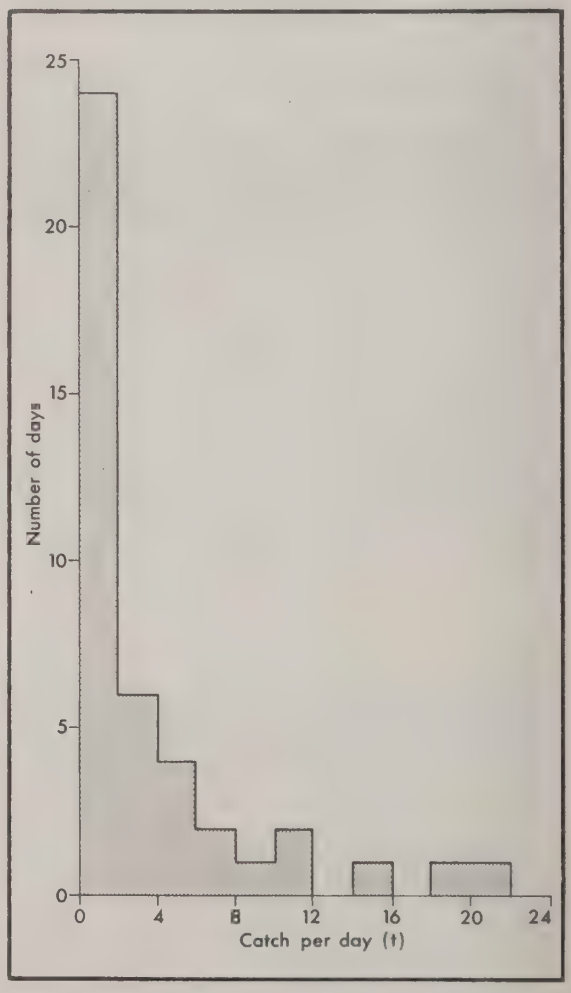

Fig. 1: Frequency distribution (number of days) of the catch rate (tonnes skipjack per day) by *Pirimai* for the period 1 January to 17 April 1972.

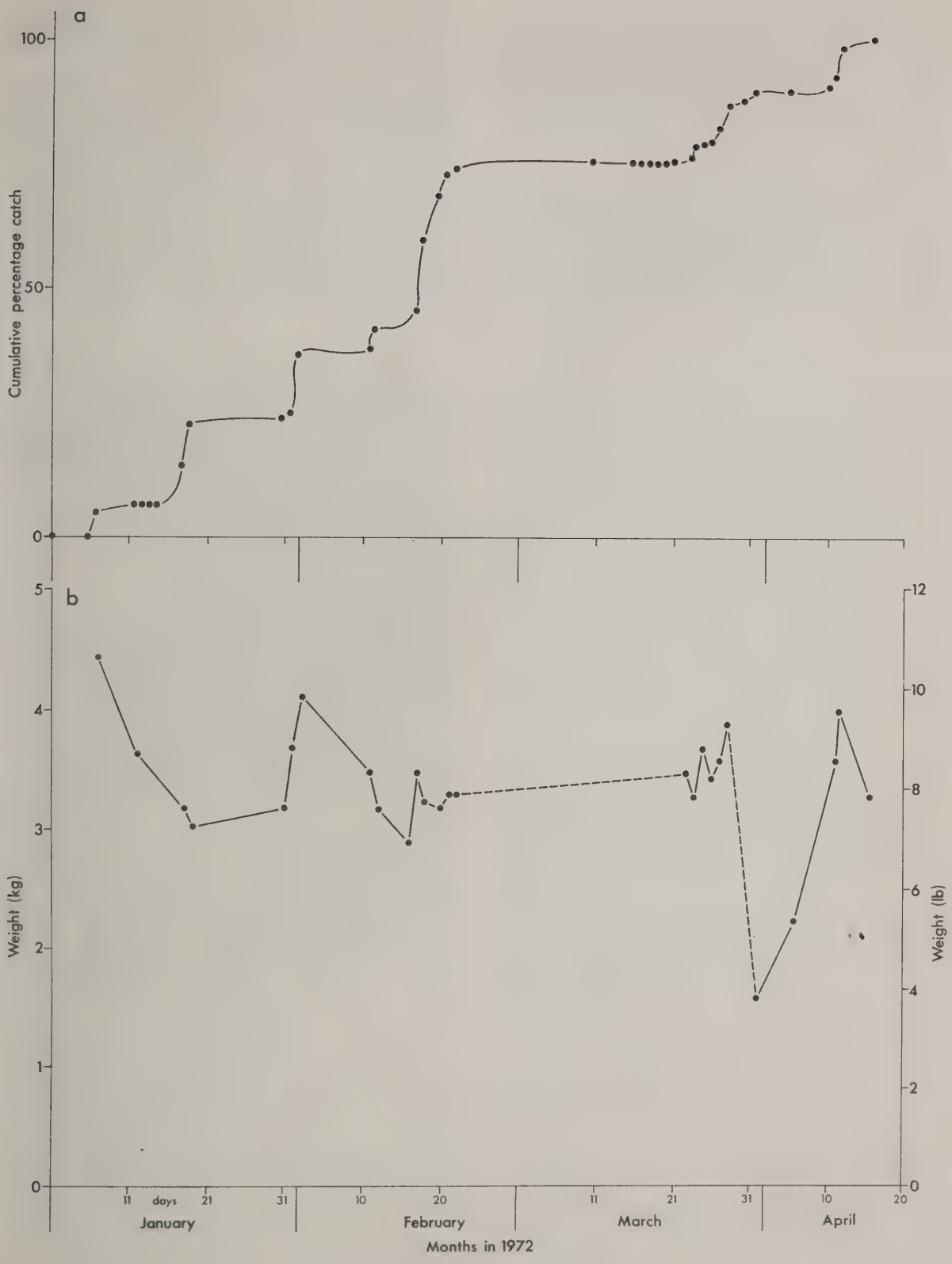

Fig. 2: a. Cumulative percentage of skipjack catch by *Pirimai* for the period 1 January to 17 April 1972. Fishing days are shown as black circles.
b. Estimated mean daily weights of skipjack caught from *Pirimai* for the period 1 January to 17 April 1972.

The 37 842 skipjack caught had an average weight of 3.4 kg. Schools of small fish (1.7 to 2.5 kg average weight) were found late in the season in both the western and eastern Bay of Plenty. Most of the daily average weights were between 3.2 and 4.5 kg, with no obvious seasonal trend (Fig. 2b). Most fish were heavier than those caught by purse seine in the Bay of Plenty in 1974-76.

In addition to mechanical and marketing difficulties, a major problem which kept *Pirimai* off the fishing grounds was that of obtaining live bait. Many fishermen talk of plentiful supplies of suitable bait-fishes, both in enclosed harbours and at sea, but catching and holding bait has often been difficult. *Pirimai's* experience has shown that it is impossible for one vessel to establish successfully both bait and tuna fishing grounds and this vessel has been converted for another fishery.

Before a similar venture is undertaken in New Zealand waters, basic research should be carried out on the bait-fish suitable for pole fishing. Such research should include studies on the distribution and abundance of each bait species, as well as on methods of catching and holding them, with the aim of establishing an independent live-bait fishery from which tuna fishermen could purchase fish as required. This works successfully elsewhere, but the economics of a separate bait fishery must be carefully examined before such a venture is undertaken.

Skipjack Fishing from Small Vessels in the Bay of Plenty

J. Plews

Pole and line (bait-boat) tuna fisherman, Whakatane

I am one of a small number of bait-boat fishermen working out of Whakatane in the Bay of Plenty. I began fishing for tuna during the 1969-70 season from an 18-ft (5.5-m) vessel, *Comrade*. In 1972 I bought the 36-ft (11-m) *Morning Star,* which I have used to fish for tuna during the season ever since. However, this has been disappointing, as tuna have been fetching crayfish bait prices. For example, 2 years ago we were getting 8 cents a pound.

New Plymouth has been suggested as a possible base for the tuna industry. I think the industry should be based in Whakatane, as this is near the centre of tuna distribution. Working from Whakatane I can cover the tuna grounds and within an hour of shore I have managed to load my boat with over 7 t of tuna. An aircraft has at times assisted in finding suitable bait and tuna schools, but usually bait-boat fishermen cannot afford the cost of aircraft hire unless they pool their resources. Therefore we have shown we can make good catches from Whakatane.

Wattie's in Gisborne have the plant required to can the tuna; what we need in Whakatane are shore handling facilities, particularly brine tanks such as were in New Plymouth. We need good stores of dead bait and suitable nets to catch bait species like anchovies close to shore. These things can be provided in New Zealand. We do not need overseas help.

Pole fishing is not hard to learn. While searching for tuna, a constant watch must be kept for gannets and muttonbirds, which feed with the tuna schools. Tuna such as skipjack, albacore, and even yellowfin often feed on bait-fish meat-balls (tightly packed ball-shaped schools of bait-fish such as anchovies and pilchards). Once tuna are found, strength and endurance are needed to pole aboard a large number of fish quickly. Last summer two men in 2½ hours poled over 6 t of skipjack from a school which was feeding on a meat-ball. Sufficient quantities of ice should be carried to hold the fish. With fishing like this it is possible to land two loads of fish in a day. In past seasons when fishing has been good I estimate that there have been more than 30 fishing days in a season, and on these occasions I have generally needed more carrying capacity.

I would like to comment now on the relative merits of one aspect of pole fishing and purse seining. I have observed that the average size of poled fish exceeds that of purse seined fish and for this reason I feel pole fishing is a better conservation method of catching because it allows the fish to grow to a larger size before they are caught.

In conclusion I suggest that more interest should be taken in, and more research carried out on, bait-fish such as anchovies.

A University Contribution to Tuna Research

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The university has contributed to tuna research through the part-time efforts of staff and M.Sc. students and the full-time researches of Ph.D. candidates. There has been little direct work on skipjack, because until the participation by Star-Kist Foods Inc. of California very limited skipjack material was available for study. Contributions have been incidental, through studies on plankton and smaller pelagic species suitable for live-bait in tuna fishing. My interest developed from a study of the schooling fish in Tasman Bay and later extended to the west coast between Greymouth and New Plymouth. An aerial survey programme revealed the existence of five types of schooling pattern.

Identification of School Types

School type 1

The schools of this type have all been sighted close to shore and generally in an inlet or harbour with a freshwater influence. The shape of the schools varies from circular to that of an extended column or thick line. Transition from the circular to the elongated pattern is usually observed as the school approaches the shore from deeper water. As the water shallows there is insufficient room to contain the school, which spreads out sideways. Its advance is stopped by the shore line and leading fish turn either right or left. Some of the fish follow each lead group and the school may divide into two columns, each of which travels along the shore line in a different direction. If a school, after following the shore line for some distance, heads into deeper water, the columnar pattern broadens and becomes first elliptical and then circular. The schools do not wander far from the outlets of streams or localities where fresh water is seeping through a beach and so parts of schools which have split up frequently meet each other and recombine.

Sometimes the columns of fish advance along a shore line in line astern, but at times a column will advance in line abreast. If a forward surge develops from the centre of the line when advancing in line abreast the line may take up a V formation. Many such school formations were netted from the fishing vessel *Joy Maree* with a beach seine 200 fathoms (366 m) long and the fish were identified as yelloweye mullet *(Aldrichetta forsteri).* Garfish *(Hyporhamphus ihi)* are frequently taken in the same hauls and either school with the mullet or are present as independent small schools which are taken inside the same sweep of the net.

Schools of type 1 are sighted throughout Tasman Bay and the Marlborough Sounds, but not along rocky shore lines exposed to wave action. Juvenile yelloweye mullet superficially resemble juvenile clupeoids, but are much hardier and are easily held in tanks. Their usefulness as live bait would depend on whether they would stay close to the poling boat after chumming.

School type 2

In the open sea type 2 schools have a more or less circular shape, but once in the Marlborough Sounds they approach the beaches and spread out into elongated crescents or columns which sweep around the shore lines of the bays at considerable speed. Seen from above the schools are deep purple, but seen obliquely from a boat they appear as a dark brown shadow. School location is often revealed by air bubbles rising to the surface and a beach seine can be set around a school detected in this way.

In some respects this school type resembles type 1, but it can be distinguished by its appearance during a restricted season in a limited part of the region. June and July are the months of major sightings. The schools are normally found in the open sea, but in winter they move into the Sounds, frequenting Queen Charlotte more than Pelorus Sound and often entering through Tory Channel on the incoming tide.

During the winter months lookouts on headlands of the Sounds direct beach seining teams to the schools. Catches over the last three winters have established the identity of these fish as jack mackerel *Trachurus declivis.* The quantities taken by beach seine during June and July in Tory Channel have been sufficient to initiate a commercial fishery, the catch being transported to Nelson for canning; further quantities are used as bait in groper fishing. Jack mackerel are unlikely to be suitable as live bait for tuna.

School type 3

The most typical feature of type 3 schools is that they occur in great number and are distributed over wide

areas of Tasman Bay, the Marlborough Sounds, and in the large inlets around the coast of D'Urville Island. The estimated average density of distribution in Tasman Bay over the years 1964-67 was 10 schools per square mile. This type of school can be seen only in calm weather, as the disturbance the fish create at the surface is not much greater than that of a cats-paw of wind. Conditions are seldom suitable for detection and recognition of such schools during a flight of 1 hour's duration over Tasman Bay. However, when visual conditions have been suitable counts of up to 500 schools in a 50 square mile area have been made.

This type of school can be seen on the surface from late spring to early autumn. The earliest sightings are made in September and the frequency of sightings increases in October, November, and December, peaks in January, and continues at this level through February and March to decline slowly in April. Numerous sightings were made in the first week of May over the period 1964-67, but by the end of the month the schools had ceased to show at the surface.

These schools are not accompanied by large flocks of sea birds, but gannets, either singly or in small groups of up to a dozen birds, are regularly seen diving into the schools. Very occasionally a flock of up to 200 gannets has been sighted, concentrating its attack in an area containing 2 or 3 exceptionally large schools, but generally when schools are numerous the gannets disperse and dive here and there on schools distributed over a wide area. On only one occasion have I seen birds other than gannets taking fish from a school of this type; these were black-backed gulls.

A characteristic feature of the appearance of these schools when seen from an aircraft is that periodically they slowly sink from sight and gradually reappear to ruffle the surface again, so that at any one time a count of the number of schools visible underestimates the total number present. Seen from a boat, the schools also resemble cats-paws of wind, but after some experience in observing them a distinction can readily be made. The sinking and resurfacing of the school provides one indication, there is the occasional flipping of a fin or tail, and at times a fish will leap clear of the water. When observed closely, air bubbles can be seen rising from the school. The sound produced by these schools as they move recalls the sound of a light shower of rain pattering on the water.

The identity of the fish species forming this type of school was established by sampling with both gill nets and lampara nets; adult pilchards 100 to 190 mm long were obtained. Pilchard schools can also be detected by echo sounder as plume-like traces on an echogram, though anchovies also give a similar type of trace.

School type 4

The main characteristic of type 4 schools is that they are attended by large flocks of sea birds, the most conspicuous of which are red-billed gulls and terns. From the air the schools can be seen to contain large fish individually visible to the naked eye from an altitude of 1000 ft (305 m) and about the same length as the wing span of the red-billed gulls. Schools are more or less circular and between 50 and 100 ft (15 and 30 m) in diameter. Frequently two or more schools may be sighted within a few hundred feet of each other and the birds will often leave one school and fly across to another. One explanation for this pattern is that the large fish are feeding on smaller fish, which they drive to the surface. After a feeding attack lasting from about 20 to 30 seconds the large fish appear to withdraw from the surface, which allows the smaller fish to sink to a depth which takes them temporarily out of reach of the gulls and terns. Birds of these species do not dive and if their prey can withdraw beneath the surface it is safe from attack by the birds until it is forced to the surface again by predator fish.

Neighbouring schools are frequently out of phase in their responses to predator fish. At the surface in one school, prey may have sunk to a subsurface level in a neighbouring school. This leads to a situation in which birds are flying from a school in the sinking phase to a school which is surfacing. Often a flock of birds is circling over each school, with a ribbon of birds linking the two formations. The flight from one school across to another is seldom completed and the direction of the birds in the flight path between them is frequently being reversed.

Schools of this type are most often seen in the outer Marlborough Sounds at their openings into Cook Strait, around the islands in Cook Strait, and around D'Urville Island. They have also been sighted in Tasman Bay, but less often in the open bay than in localities with strong tidal currents. Sightings have been made in all months of the year, though the schools are more numerous between November and April.

These schools have frequently been encountered by staff on *Tīrohia* or on fishing boats. Lures have been trolled through the schools and strikes obtained from barracouta *(Thyrsites atun)* and kahawai *(Arripis trutta)*, with more of the former being taken than the latter. Examination of stomach contents has usually shown that the predators have been feeding on clupeoid larvae, post larvae, or juveniles. In the stomach contents of barracouta and kahawai, examined over the period 1964-68, anchovies *(Engraulis australis)* were encountered most often, sprats *(Sprattus antipodum)* were next in abundance, and pilchards *(Sardinops neopilchardus)* featured least frequently. Occasionally a school of barracouta or kahawai accompanied by birds had been feeding on euphausiids, but on the west coast clupeoid fish constituted the major component of the diet.

School type 5

This type of school activity has been seen on the seaward boundary of Tasman Bay and during 1973 was common on the west coast between Greymouth and New Plymouth. It is less easy to see from the air, as the birds associated with it are black-backed; they include fluttering, fleshfooted, and Buller's shearwaters. The

small fish on which they feed are inconspicuous. Aerial communication between spotter plane and boats equipped for tuna trolling has shown that albacore tuna are usually the predator fish responsible for driving the prey fish into the range of the birds. Albacore do not harry prey fish as much as kahawai and barracouta, so that the prey seldom break the surface. They are thus not readily available to the non-diving "white birds" (terns and red-billed gulls), but come within range of diving birds.

Stomach contents of albacore off the west coast have usually shown, however, that the prey fish are the same as in the kahawai- and barracouta-type school, namely, juvenile anchovies, sprats, and pilchards. When under attack by kahawai or barracouta the prey fish tend to scatter and leap out of the water, whereas when under attack from albacore they frequently bunch into compact schools known to fishermen as meat-balls.

Size of Bait-fish for Live-bait Fishing

While working on various troll and pole and line boats I have observed that tuna are not readily attracted when they are being offered bait-fish which is not the same size as that on which they were feeding before the boat made contact. For example, while on *Pirimai* I saw albacore approach, examine, and then shy away from pilchards 16 to 20 cm in length when the main school fish in the area were 6- to 9-cm anchovies.

Catching Bait-fish

Bait-fish are readily caught in Tasman Bay and the Marlborough Sounds by lampara net or purse seine. Local fishermen use dead pilchards for groper bait and catch them from dories by use of lampara nets. Teams of up to nine men fish the nets by hand, but there would be a need to mechanise this method to catch live bait economically. *W. J. Scott* demonstrated that pilchards could be caught by purse seine in Tasman Bay when in one set around a cluster of plumes located by echo sounder a catch of 30 t was made. *W. J. Scott's* net was obviously too big to be used for live-bait fishing. In Canada a scaled-down version of a drum-operated purse seine is used by research teams to capture sockeye fingerlings in the inland lakes, and such gear might prove suitable for taking small schools of live bait.

There are two other aids to catching anchovy and pilchard schools. One involves locating the schools from phosphorescence when they school at the surface on dark nights. In the South African pilchard fishery the spotter plane flies over the fishing grounds at night and notes the areas where schools are plentiful from their phosphorescence. The boats are directed into this area until they make sonar contact with the schools, and they use sonar for the final set. In the Californian live-bait fishery I have seen a boat make a successful set by encircling a patch of phosphorescence.

The other aid is to attract the bait-fish to a light. In the Californian fishery some boats carry dinghies with large lighting systems. The dinghy is left with its lights on for a time and then a set is made around it. In the Marlborough Sounds I have successfully caught pilchard and anchovy juveniles after attracting them alongside the boat with a 12-volt car bulb sealed into an Agee jar. A polystyrene float is used to keep the cable out of the water. The fish swim in a circle where the light flux has an optimum attraction for them. On full 12 volts the circle is several metres in diameter, but if the light is gradually dimmed, the fish can be brought right up to it so that they can be hauled out with a plankton net or a dip net.

Size of Boat for Live-bait Fishery

In New Zealand we have tended to think that a relatively large boat is required for live-bait tuna fishing, as in the *Olwyn* and *Pirimai* ventures. In California I have seen sports fishing boats 5 m in length taking on live bait for a day's fishing out of Long Beach. On the Greymouth tuna grounds I have seen four-man Japanese crews carrying out pole and bait fishing from boats of about 7 m in length. Over the period in which I observed them they were doing as well as *Pirimai*. If we are going to develop the skipjack fishery fully, I believe there is a place for the live-bait boat, and the secret might lie in learning to think small!

Opening Address, Second Day

The Honourable Duncan MacIntyre

Minister of Agriculture and Fisheries

Many people, directly or indirectly involved in the fishing industry, are concerned and even apprehensive about the development of tuna fishing in New Zealand waters, particularly by the purse seine method. This conference has been sponsored by the Fisheries Research Division of my Ministry to keep all parties informed, and these include the sports fisherman who seeks a record yellowfin or delectable albacore.

In 1968 the Fisheries Committee of the National Development Conference (NDC) emphasised the need to increase substantially our fish exports and noted that one of the major opportunities for expansion lay in the exploitation of pelagic resources. The presence had already been established of substantial stocks of pelagic fishes around New Zealand which might be caught provided techniques could be developed and suitable market outlets found. Some species, though abundant, have a relatively low value and for these bulk catching techniques would need to be developed and could possibly be applied also to higher value species.

The Fisheries Committee of the NDC estimated that the potential annual yield of albacore tuna could reach 2000 t. Landings reached as much as 1000 t in the 1974-75 season, and high hopes were generated. However, the committee was much more conservative about skipjack and estimated an annual yield of only 750 t. Last season nearly 5000 t were taken, and by all reports it was a bad season in terms of both weather and low sea temperatures. This underestimate illustrates the need for background data on this and other species and the importance attached to gathering data which will serve as a basis for future planned expansion.

Purse seining was envisaged as the principal bulk catching method supplemented by pole and line fishing and by trolling. Because of the highly specialised nature of purse seining and the high initial cost it was considered most important to test this type of fishery by importing or chartering a suitable vessel plus key members of her crew to prove the resource and prove that the method could be used successfully in our waters. Despite setbacks which have already been referred to, the chartered vessel *Paramount* did prove that skipjack in particular could be caught in quantity.

These encouraging results led to the setting up last year of the New Zealand Pelagic Fisheries Development Company, which has grasped the opportunity to test the markets further so that we can develop what we all hope will be a lucrative venture for New Zealand.

Not only must we be seen to be developing our fisheries and fishing industry, but we must also be seen to be capable of competing with foreign vessels in terms of quantities of fish caught. How else can we claim the right to what we want from a 200-mile economic zone?

In terms of markets there are three problems: first to find them, second to get the best prices, and third to get the fish to those markets as economically as possible. Quality undoubtedly affects prices and it must be realised, for example, that southern bluefin tuna, which the Japanese catch in our waters, can fetch up to $7 a pound, but they realise such prices only because they are refrigerated immediately to -50°C and stored at -40°C. There are no freezers in this country capable of doing this. Nevertheless, our technology in freezing and in handling skipjack must be on a par with that of other potential exporters.

The United States takes about 45% of the world catch of albacore and skipjack; so it is logical that it should be viewed as the principal potential market. However, the cost of freight from New Zealand is high and ever increasing, and it is particularly high for fish largely because of the need for specialised transport and also because of the relatively small scale of exports. Development to a larger scale could help cut unit costs of freight on all fishery exports. Moreover, provided the techniques of bulk fishing can be developed, the input to local industry could make it worth while to consider further processing here, for example, canning.

Some members of the fishing industry are concerned that large-scale developments by a limited number of companies could adversely affect their activities. This is not our intention and, as I see it, this type of development could increase the export opportunities for the whole of the fishing industry. Incidentally, albacore are seldom taken by purse seine anywhere in the world and observations made in New Zealand suggest that they

cannot be caught that way here either; so the albacore fishermen, many of whom began in the Bay of Plenty, are unlikely to find themselves in competition with seiners.

Similar fears have been expressed by skipjack pole and line fishermen, but, as you have heard, the distribution and behaviour of the fish and the sizes of the schools fished by the two methods are unlikely to overlap, and therefore I do not expect there will be any conflict of interests. However, it is something of which we are aware and care will be taken to ensure that developments proceed in parallel rather than in competition.

There has been a suggestion that with the advent of the bigger vessels more attention will be paid to their fishery by research and management staff. Inevitably this has happened to a small degree, but you should not overlook the work on pelagic fish that has already been done over the past 10 to 12 years. For some species such as albacore, for example, monitoring and prediction of where the fish are likely to occur should become a matter of routine which could be operated jointly by management and industry.

Whether the Government would consider it worth while to extend the aerial spotting service beyond that which is now undertaken is likely to depend on how such additional effort may be to the national economic advantage. I do know that some countries consider it worth while to guide their fishermen in this way and, as you will hear later on, there is no doubt that "aimed" fishing of this type is much more profitable.

In considering the overall development of the industry it should also be noted that large-scale fishing for skipjack is directed towards using a resource which until now has been exploited almost exclusively by foreign vessels. If we can demonstrate our ability to use these resources to the full, we need feel under no obligation to grant concessions to other countries within our area of jurisdiction. This means a rapid acceleration of our fishing effort in this field. With the impending outcome of the Law of the Sea Conference it is absolutely essential that we move into the "big league" as soon as possible.

However, as far as tuna are concerned we may have to agree to some international limitation of the total catch of these highly migratory species. With the contribution that we make from studies of the species plus our active interest and support for the international assessment programme for skipjack of the west tropical Pacific, as well as an active participation in the fisheries themselves, we must be in a good position to demand the right to take part in discussions aimed at determining just what the overall rate of exploitation should be.

There are many pressing decisions ahead for the industry, for the Cabinet Economic Committee, and for officials working with them. These will inevitably involve discussions and considerations of policy with respect to joint ventures, imports of fishing vessels and fish, labour relations, and so on. I am fully aware of the need for action and have asked for a detailed report on the fishing industry which will provide a basis from which to work when it comes to considering finance and also conservation.

I have enthusiasm for, and great faith in, the future of the fishing industry and I regret that I have not been able to be present for the whole of this tuna conference. Nevertheless, I look forward to being fully informed of all that takes place and hope that you will all benefit.

The *Paramount* Project: A Purse Seine Survey of New Zealand's Skipjack Resource

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Subject: *Physics*

Title: FOUNDATIONS OF RADIATION HYDRODYNAMICS

Authors: DIMITRI MIHALAS, Senior Scientist, and BARBARA WEIBEL MIHALAS, Visiting Scientist, both of the High Altitude Observatory, National Center for Atmospheric Research, Boulder, Colorado

The Book: This is a systematic exposition of the physics of flows in which radiation makes an important or even dominant contribution to the total energy and momentum in moving fluids. The volume makes an attempt to develop both hydrodynamics and radiation transport within a single, coherent conceptual framework so that specialists in each of these disciplines can immediately use their expertise to understand the physics underlying the phenomena of interest. Particular emphasis is placed on the close relationship of radiation hydrodynamics to ordinary fluid dynamics, displacing the underlying unity and parallelism of the two formalisms. The theory discussed has a wide range of applications to diverse astrophysical phenomena, including laser fusion, reentry vehicles, and intense explosions.

Readership: Graduate students and professionals in physics and astronomy

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recommended setting up a Government-supported enterprise with two purse seiners and a barge-mounted fish-meal plant to fish in the Bay of Plenty to assess the commercial viability of pelagic fishing.

Payne's recommendations were only partly implemented. The success of *W. J. Scott,* and later of *Kaiti,* led Wattie's to build *Marine Countess.* These Gisborne-based vessels clearly demonstrated that trevally, kahawai, and mackerel could be caught in quantity in summer and their catches encouraged Wattie's, with the aid of Government finance, to build a fish-meal plant at Gisborne. In this way one objective of Payne's recommendations was fulfilled.

There was still investor reluctance to be overcome and, though local vessel performance was encouraging, there was no standard against which it could be calibrated. As the vessels trawled in winter, the winter purse seining prospects were unknown. The local vessels did not have nets suitable for skipjack purse seining and did not set on skipjack. The 132-ft (40-m) American-style purse seiner *Espirito Santo* (almost identical to *Paramount*) was chartered by a New Plymouth company for part of the 1970-71 season, but she met with little success. Thus there was a need for a survey by a specialist purse seine vessel with skilled crew to assess the distribution, abundance, seasonality, and vulnerability to purse seining of surface-schooling fish, particularly skipjack, around New Zealand.

In 1973, after negotiations with several parties, the Government entered into a joint agreement with Star-Kist Foods of California to carry out such a survey with the Star-Kist-owned *Paramount.* Initially the survey was to be of 1 year, but this was later extended to include a second skipjack season, as the first season was disrupted by the fuel crisis and other problems.

Paramount is 132 ft (40 m) long and carries 330 to 350 t of tuna. The tuna net was 550 x 55 fathoms. She was originally built as a pole and line vessel and later converted to purse seining. She began fishing in early January 1974 and spent January surveying the west coast and then around North Cape south to Mayor Island on the east coast and back to New Plymouth. Eighty tonnes of skipjack were caught in 14 sets. Schools were seen off New Plymouth, Knuckle Point, the Poor Knights (16 schools of 100 to 600 t), Great Barrier Island, and Mayor Island.

After an aerial survey of the west coast *Paramount* surveyed the east coast of the North Island and from 7 to 16 February fished in the Bay of Plenty. Numerous schools were sighted and despite fishing days lost through bad

weather 26 sets were made. Thirteen of these were successful and filled *Paramount's* wells with 325 t of skipjack.

Because of the fuel crisis and because pre-arranged cold storage in Tauranga was not available, *Paramount* steamed to American Samoa to offload at the Star-Kist cannery in Pago Pago. On her return she carried wells full of fuel for her future use. In all, offloading and preparation for fishing took 25 days. Aerial surveys showed that skipjack schools were present throughout this period. *Paramount* sailed on 14 March, but the following 7 days were lost through bad weather. Aerial surveys under poor conditions found surface schools of skipjack throughout most of this period.

Sightings then fell off in the Bay of Plenty and for the rest of the season the survey was on the west coast. Sightings were poor and significant quantities were seen only off Hokianga Harbour and off Greymouth. No skipjack were seen after 9 April. The season's catch was 429 t. Positions of sets made in the season are shown in Fig. 1.

Obviously the objectives of the survey had not been met, because, though skipjack had been readily purse seined at high catch rates, much time had been lost and efforts to survey broad areas had reduced catches. It was therefore agreed to extend the survey for a further skipjack season, during which *Paramount* would fish as closely as possible to commercial practice and not attempt to survey large areas.

During the 1974 winter *Paramount* fished for mackerel, trevally, and kahawai. Much time was lost owing to slow unloading, insurers' survey, breakdowns, and bad weather. Only 16 days were spent fishing and the catch was 570 t of jack mackerel, 25 t of kahawai, and 26.5 t of trevally.

In the 1974-75 skipjack season aerial surveyors first found skipjack on 28 November, and in mid December

Fig. 1: Positions of sets made in 1973-74 season.

over 1500 t were present in large schools in the White Island-Whale Island area. However, because of breakdowns *Paramount* was unable to fish until 3 January. From subsequent catch rates it seems likely that she could have caught at least 300 t (one trip) before New Year.

Between 4 and 8 January 225 t were caught in the Bay of Plenty in 6 out of 12 sets. Almost 200 t were lost from one set when lines failed under strain. A new refrigeration plant was fitted while the catch was offloaded. From 15 to 24 January 205 t were caught in 18 sets, 7 of which were successful. Schools of up to 200 t were seen. This fish was offloaded in Mt Maunganui between 25 January and 2 February. From 3 to 11 February, despite 2 days lost because of bad weather, 13 sets were made and 360 t caught in 5 successful sets. One catch (155 t) was the largest ever made by *Paramount* or her skipper. Schools of 200 t were again seen. Offloading and maintenance took from 12 to 15 February. Aerial surveys showed 70 t in 15 schools on the west coast (off Gannet Island), compared with 200 to 300 t in 20 schools at Motiti and 200 t in 4 schools at White Island.

From 16 February to 2 March *Paramount* again fished in the Bay of Plenty. Thirteen sets were made and 270 t of skipjack caught. Up to 700 t of fish were seen from the air on individual flights, but sightings fell off during the period. Five days were lost while making repairs or through bad weather. During offloading (3 to 8 March) aerial surveys from Hawke Bay to Great Barrier Island on the east coast and from Manukau Harbour to New Plymouth in the west sighted fish in Hawke Bay and near White Island. Bad weather delayed sailing until 16 March. Further aerial surveys reported large areas of scattered jumpers and small schools, with seinable schools off Manukau. However, when the vessel arrived in this area the schools had dispersed. Skipjack were also sighted in the South Taranaki Bight in early April, but no catches were made. The positions of sets made in the 1974-75 season are shown in Fig. 2.

During the 1974-75 season *Paramount* caught 1000 t of skipjack in 35 fishing days. Probably a full load was lost before New Year. Twenty-five days were spent offloading at an average rate of 40 t per day. *Paramount* showed that given quicker offloading and a trouble-free season a purse seiner of her size could land 1500 to 1800 t in the 3- to 4-month season. Comparable data on catch rates from other areas are not readily available, but comments from knowledgeable members of the California purse seine fishery indicate that this catch rate is very good.

At this stage some points can be made on purse seining in the New Zealand situation. Of overall importance to any future fishery based on this method is the right boat in the right condition. *Paramount* was a suitable vessel, but she lost much time through breakdown of engines, freezing equipment, generators, and other parts. Preventive maintenance is important for averting many of these breakdowns. However, because some breakdown is inevitable, adequate spares should be carried, particularly if American or other overseas-built

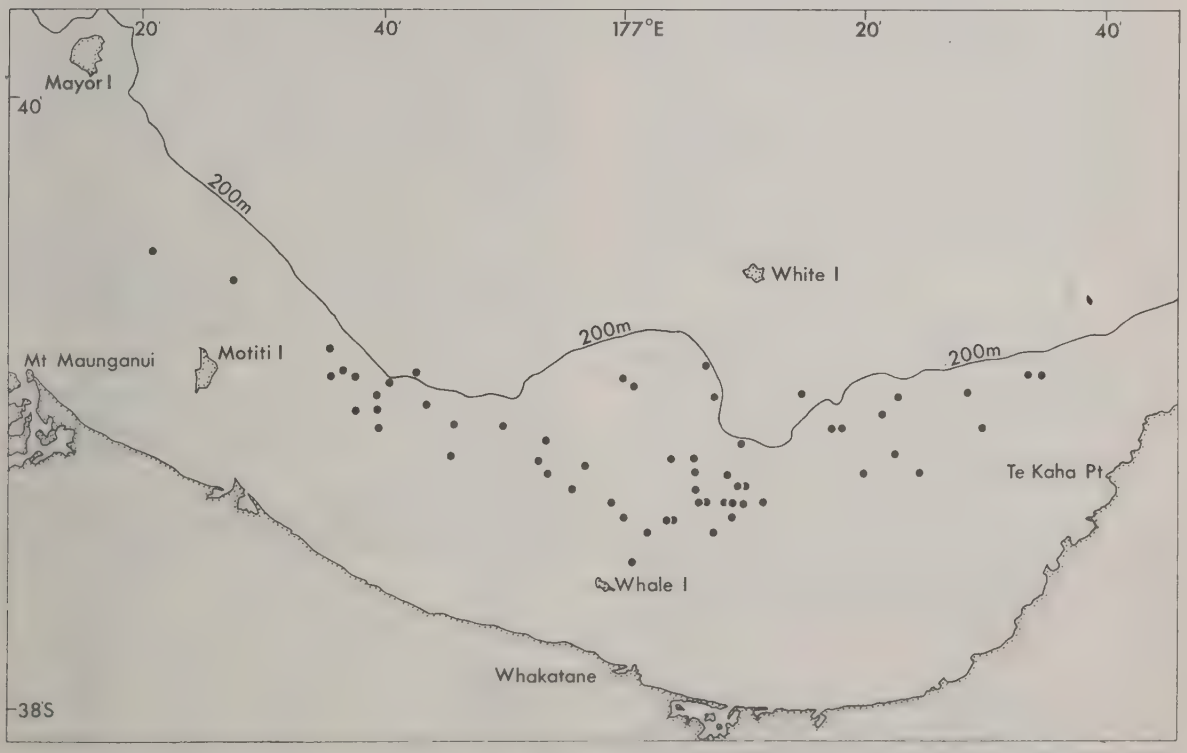

Fig. 2: Positions of sets made in 1974-75 season.

TABLE 1: Skipjack sightings by month, 1973-74 and 1974-75 seasons

Area	1973-74 Jan	Feb	Mar	Apr	1974-75 Nov	Dec	Jan	Feb	Mar	Apr
North Cape to Cape Brett	†	-	0	0	-	†	-	-	†	-
Cape Brett to Cape Colville	††	0	0	0	-	†	0	-	†	-
Cape Colville to Mount Maunganui	†	0	0	0	-	†	0	†	†	-
Mount Maunganui to East Cape	†	††	†	†	†	††	††	††	†	0
East Cape to Gisborne	0	†	0	0	-	†	0	-	†	-
Gisborne to Cape Turnagain	-	†	0	0	-	†	-	-	0	-
Cape Turnagain to Cook Strait	-	0	-	0	-	-	-	-	-	-
Westport to Cape Egmont	0	0	†	†	-	-	-	0	0	†
Cape Egmont to Kaipara	†	0	††	†	-	-	-	†	†	†
Kaipara to North Cape	0	†	††	†	-	-	-	0	0	-

- No survey
† Some sightings
†† Good sightings
0 Surveyed but no sightings

vessels are being used. Spares availability for such vessels in New Zealand is limited.

Storage on board must be capable of handling and rapidly freezing large quantities of fish. Rapid freezing is important because skipjack have a high body temperature, which leads to accelerated deterioration of dead fish. Very large quantities occasionally have to be handled in a short time. For example, during last season *South Pacific* caught 195 t of skipjack in one day. This quantity represented about 107 500 fish, or if laid end to end a line of fish over 32 miles long! Rapid offloading is essential to reduce loss of fishing time. Manhandling individual fish in the wells does not seem appropriate to New Zealand conditions. Storage and transport ashore can be another problem. If quality is to be maintained, it is important to avoid thawing and refreezing. Delays before chilling and freezing also adversely affect quality.

Air support was demonstrated to be invaluable both in aiding the vessel to select the most appropriate school to set on and also in making quick surveys of extensive sea areas to select the best fishing area.

The most significant findings of the *Paramount* survey in relation to the fishery itself are discussed below.

The skipjack purse seine season extends from early December to late March. The peak of the season appears to be February, but sightings show large fluctuations throughout the season. Future work will indicate if these are correlated with moon phase or weather patterns.

The range of skipjack around New Zealand is from off Greymouth on the west coast, north around North Cape, and south to the southern Wairarapa, but the main area of abundance is on the east coast from north of Gisborne to North Cape and in particular in the Bay of Plenty. Areas of sightings by month are given in Table 1. There was no evidence from vessel or air surveys of large quantities of fish further off shore. Most sets made were within the 12-mile limit.

The school size of skipjack in the New Zealand area was also clearly demonstrated. In both 1973-74 and 1974-75 schools estimated at over 200 t were seen, but school size fluctuated considerably during the season. *Paramount* avoided both very large schools (over 150 t) and small schools (less than 5 to 10 t). Many schools (58% of those set on) contained less than 50 t of skipjack and only 23% of the schools were over 100 t. School size and success rate are shown in Table 2; the smaller the school the higher was the success rate.

Table 3 shows the reasons why schools were missed. Most of the schools lost were lost during setting and before pursing began, by fish either diving under the net while setting took place or swimming out by the skiff or under the towline.

Depth affected fishing success. In the 1974-75 season sets were made in depths from 74 to 267 m. All but five of the successful sets were made in water shallower than

TABLE 2: Size of skipjack schools set on by *Paramount* and fishing success rate in relation to size of school. (No estimates were made for 14 of the unsuccessful sets or for the 2 partly successful sets.)

School size (t)	Number of schools Caught	Lost	Total	Success rate (%)
<10	5	1	6	83
10-19	10	5	15	67
20-49	18	11	29	62
50-99	7	9	16	44
100-149	2	11	13	15
>150	1	6	7	14
	43	43	86	

TABLE 3: Reasons why 57 sets were unsuccessful (total sets 102, 43 successful, 2 partly successful)

Fish dived under net during setting	25	35 before pursing
Fish swam out by skiff during setting	6	
Fish swam out under towline	4	
Fish swam out under boat during pursing	16	
Roll up or rip (net problems)	5	
Fish let go (wrong species)	1	

110 m and success rate was 69% in sets shallower than 90 m. Success rate was slightly higher in blue-green water than in clear oceanic water, but data are too few to state this categorically. Success rate showed no clear relationship to sea surface temperature, thermocline depth, or temperature gradient, though fish were less easily caught early and late in the season.

In both years catches mainly comprised fish 43 to 59 cm in length. In 1973-74 catches most fish were 44 to 48 cm and weighed about 2 kg, with some larger fish being taken late in the season. In 1974-75 fish were larger (50 to 52 cm, 3 kg). However, the proportion of small fish, some down to 33 cm, increased towards the end of the season. In both seasons a different (larger) size group of fish was taken by the Whakatane small-boat fleet.

Paramount demonstrated that New Zealand has a considerable resource of catchable skipjack and that a vessel of her size could expect to catch 1500 to 1800 t of skipjack in a season extending from early December to the end of March.

Distribution and Abundance of Skipjack, 1975-76

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Skipjack were subjected to intensive fishing pressure in New Zealand waters during the 1975-76 season. Through observations from five purse seiners, Bay of Plenty bait boats, a number of fishing vessels in other regions, and three spotter planes much information became available on the distribution and abundance of skipjack in surface waters during the season. This information forms the basis of my paper.

The whole of the North Island coastline was surveyed at some time during the season. Skipjack schools were found as far south as Mahia Peninsula on the east coast and South Taranaki Bight in the west. However, as in past seasons, the main concentrations were on the north-east coast between East Cape and North Cape. Expecting this, fisheries research staff set up a programme to conduct regular aerial surveys of the north-east coast throughout the season. Surveys were conducted from 31 October to 2 November and from 9 to 11 December 1975 and in 1976 from 2 to 5 February, 27 to 28 February, and 3 to 6 April. Between these survey periods observations of schooling fish were made from vessels and spotter planes operating in the area. As a result, a more or less continuous record of school sightings was kept for this area throughout the season.

Observations in other areas, particularly the west coast of the North Island south of Reef Point, were less than continuous, mainly because of the limited manpower and facilities. However, within the limitations of the project, sightings of fish in close surface schools were made with the date, locality, number, and size of schools being recorded. For example, on 1 November 1975, 40 schools averaging 50 t in size were sighted off Reef Point in the area bounded by 34° 46′ S and 173° 31′ E, 34° 43′ S and 172° 37′ E, 35° 11′ S and 172° 58′ E, and 35° 11′ S and 172° 48′ E. As no account was taken of fish dispersed over wide areas (finners and jumpers, see Scott 1969) or of subsurface fish, our estimates of skipjack on the New Zealand coast last summer are probably underestimates.

In the analyses of sightings by area data were divided into weekly blocks (Table 1). To lessen the possibility of duplication of sightings, schools of similar size and type which were recorded within 12 miles of each other on consecutive days were considered to be the same fish. Sightings from all sources were also grouped on a daily basis and days when there were no sightings, no sightings effort, or when poor weather prevailed were noted (Fig. 1).

Schools of skipjack were sighted on 68% of the days between November 1975 and March 1976.

Skipjack were first reported on 7 October near White Island in two foaming schools (Scott 1969) of 50 and 80 t. The sightings were made during the week 26 October to 1 November off Reef Point (2000 t) and between Cavalli and Mokohinau Islands (105 t). The quantity of fish off Reef Point fell to 480 t by mid November and to about 30 t by early December. Surveys of this area during the rest of the season occasionally recorded small quantities of skipjack (Table 1).

The next major group of fish was sighted near White Island. Some 1400 t were first seen on 4 December in 16 large schools. By 6 December the quantity had increased to 3000 t, with a number of the schools over 200 t. However, on 9 December these fish had mostly disappeared from the surface, and an aerial survey of the Bay of Plenty sighted only 54 t in 19 schools of 1 to 5 t each. At this time skipjack were also seen near Mercury Islands (135 t in two schools), north-east of Great Barrier Island (165 t increasing to 365 t on 12 December), near Mokohinau Islands (25 t), and north of North Cape (36 t).

Poor weather restricted activities from 14 to 17 December and on 18 December 1000 t were sighted in large schools off Great Barrier Island. No fish were seen here on the 19th, but they showed again on 20th (950 t) and subsequent days (21st 700 t, 22nd 120 t) until 24th (30 t), when poor weather again intervened. The only other sightings in this area were on 23 February (106 t) and 22 March (15 t).

Poor conditions prevailed from 25 December to 2 January. On 3 January 1600 t of skipjack were sighted in 31 breezing schools (Scott 1969) in Great Exhibition Bay. A further 600 t were seen off Home Point. This north-east area, particularly between Cavalli Island and North Cape, remained the centre of skipjack abundance until late February. Quantities of skipjack seen when weather allowed ranged from 55 t (13 January) to 2102 t

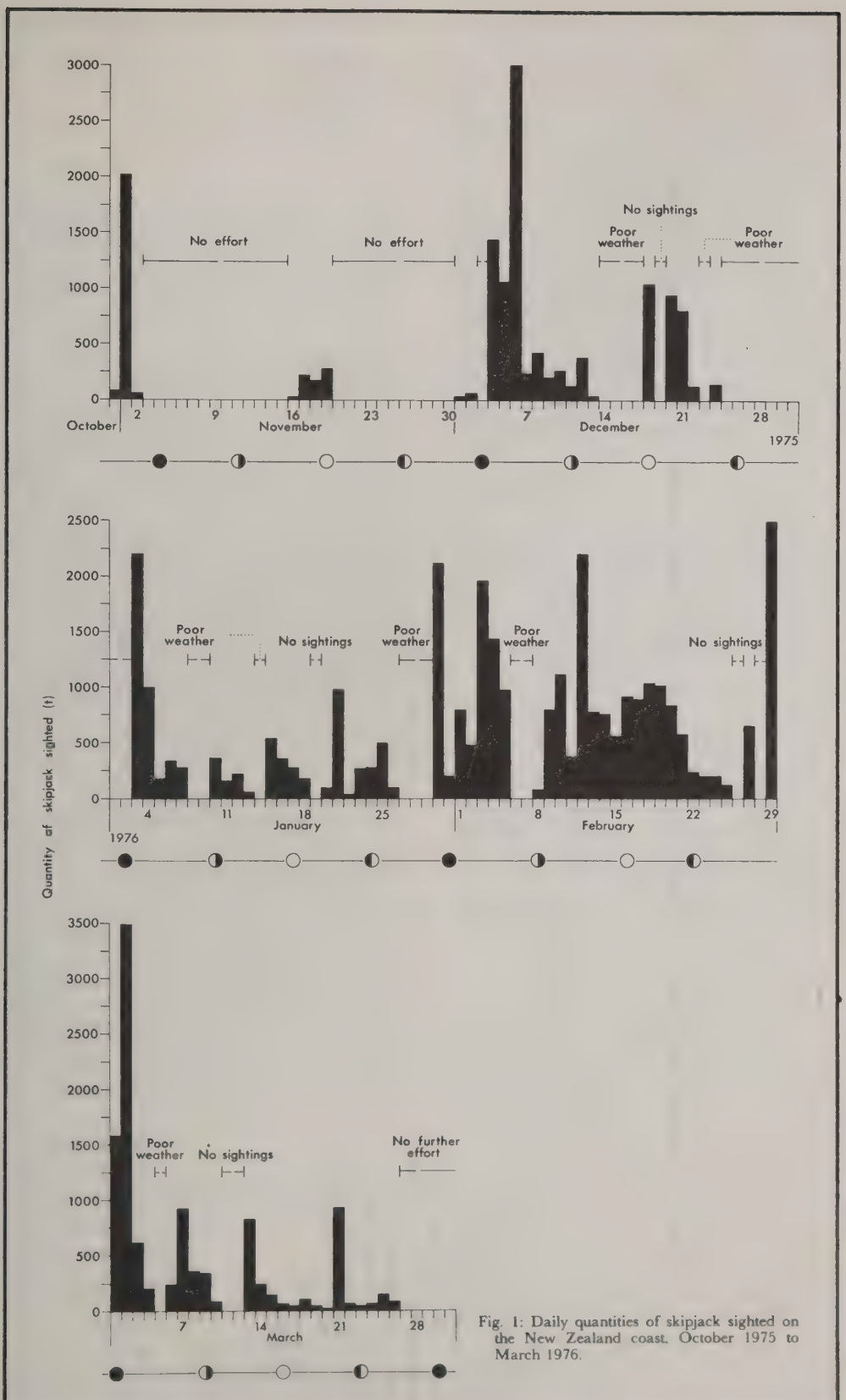

Fig. 1: Daily quantities of skipjack sighted on the New Zealand coast. October 1975 to March 1976.

TABLE 1: Quantities of skipjack sighted in tonnes per week in different areas on the New Zealand coast during 1975-76. (Dates given begin each week.)

Areas	26 Oct	2 Nov	9 Nov	16 Nov	23 Nov	30 Nov	7 Dec	14 Dec	21 Dec	28 Dec	4 Jan	11 Jan	18 Jan	25 Jan	1 Feb	8 Feb	15 Feb	22 Feb	29 Feb	7 Mar	14 Mar	21 Mar
Reef Point to Pandora Bank	2 000	*		484		30									16					40		
North of North Cape							40								38	1 080	30	192				
North Cape to Cavalli Island										1 600	1 000	1 180	975	2 597	2 512	1 107	2 344	416				20
Cavalli Island to Mokohinau Islands	105	50					25			600	353	9										
Mokohinau Islands to Mercury Islands				26			365	1 000	500									106				15
Mercury Islands to Mayor Island							135		450					25	162	1 817	154	70			14	37
Mayor Island to Waikawa Point						3 000	450				50	160	221	70	37	115	543	463	3 210	915	231	11
Waikawa Point to Gable End Foreland												20								780	159	
Gable End Foreland to Portland Island																					50	90
South Taranaki Bight																						159
New Plymouth																						770
TOTALS	2 105	50		510		3 030	1 015	1 000	950	2 200	1 403	1 369	1 196	2 692	2 765	4 119	3 071	1 247	3 210	1 735	454	1 102

*No sightings or no sightings effort

TABLE 2: Quantities of skipjack sighted during each moon phase from 29 October 1975 to 26 March 1976

Moon phase	Sightings (t)	Percentage of total
New moon	23 362	42
First quarter	12 295	22
Full moon	10 736	19
Last quarter	9 226	17
TOTAL	55 619	

(30 January) per day with a mean of 514 t per day. The maximum showing was after a 3-day storm. Weekly showings in this area were consistently high (Table 1), ranging from 2597 t (late January) down to 416 t (late February), after which no further fish were seen until a 20-t school was sighted off Cavalli Island on 23 March.

The next concentration of skipjack was seen near Slipper Island. Quantities observed on any one day rose from 25 t (31 January) to over 1000 t (12 February). During the week 8 to 14 February 1817 t were seen. In late February fewer fish in smaller schools were sighted, with small quantities being observed sporadically until the end of the season.

After the disappearance of the large body of fish from the White Island area in December, skipjack showed in only small quantities in the Bay of Plenty for most of January and February. Some daily sightings were 100 t (5 January), 28 t (21 January), 70 t (26 January), and in February 22 t on 3rd, 300 t on 17th, and 455 t on 27th. However, on 29th over 2000 t appeared at the surface. This quantity rose to 3210 t by 2 March and fell away through the month to 915 t (7th), 310 t (10th), 63 t (16th), and 11 t (26th), after which no further schools of skipjack were seen in this area.

Very few schools were seen between Waikawa Point and Portland Island on the east coast (Table 1). The only substantial quantity of skipjack seen (780 t) was near East Cape on 13 March (Fig. 1). Other late season sightings were made off New Plymouth (770 t) and in the South Taranaki Bight (159 t) during the last week in March. There were no further sightings of skipjack schools on the New Zealand coast after 28 March. However, there were reports of scattered skipjack in the Bay of Islands during April and May, at Three Kings Islands in May, and south of Mercury Islands in June.

It is clear from Fig. 1 that there were large fluctuations in the quantity of skipjack sighted during the season. It is possible that these fluctuations were related to weather conditions or moon phase, or both of these. On three occasions (mid December and early and late January) there was a period of few sightings followed by poor weather and then a striking increase in the quantity of skipjack sighted. On four occasions (early in each of the months December to March) there were large increases during the period new moon to first quarter. Of the total quantity of skipjack sighted, 42% were seen during this phase, 22% in the first quarter, 19% during full moon, and 17% in the last quarter (Table 2). The increased availability of skipjack at the surface during new moon can probably be directly correlated with the observed peaks in catch and effort in the 1975-76 purse seine fishery for skipjack. [See G. Habib's paper on page 40.] Future investigations should help to substantiate or refute the possible correlations between fluctuations in quantities of skipjack at the surface, changing weather patterns, and moon phase.

Summary

Intensive observations from fishing vessels and aircraft were made of surface schools of skipjack in New Zealand waters during the 1975-76 season. The most intensive effort was off the north-east coast. Date, locality, number, and size of schools were recorded and sightings analysed on a daily basis for the whole of the New Zealand region and on a weekly basis in relation to 11 areas on the coast. The first schools were sighted off White Island in October, the last in South Taranaki Bight in late March. Sightings centred around the appearance and disappearance of large bodies of fish in the different areas during the season. This occurred particularly at times after spells of poor weather and during the moon phase new moon to first quarter. Over 40% of the total quantity of skipjack were seen at these times. Up to 4000 t were seen at the surface during any week, 3500 t on any one day. Most of the sightings were made in the area from North Cape to Cavalli Island.

REFERENCE

SCOTT, J. M. 1969: Tuna schooling terminology. *California Fish and Game 55*: 136-40.

The 1975-76 Purse Seine Skipjack Fishery

G. Habib

Scientist, Fisheries Research Division, Ministry of Agriculture and Fisheries, Wellington

The skipjack is in life a steel blue colour above and whitish yellow below with four to six conspicuous dark stripes on each side of the body. It has the typical bullet shape of the tunas with numerous streamlining features. This highly mobile and gregarious species grows to over 90 cm (36 in.) long and 18 kg (40 lb) in weight, though in New Zealand waters skipjack are usually about 50 cm (20 in.) long and 2.5 kg (5.5 lb) in weight. Skipjack occur throughout the oceans of the world between latitudes 40° N and 40° S.

During summer skipjack migrate into New Zealand waters from the north, usually moving as far south as Cook Strait. Surveys in earlier years, for example, the *Paramount* surveys, have shown that the number of fish in this migration can be considerable. These surveys also showed that skipjack in New Zealand waters can be caught in quantity by purse seine. At the completion of the *Paramount* surveys it was concluded that further fishing trials on a commercial basis were desirable to prove the extent and resilience of the skipjack resource and to determine the best and most economic fishing unit for the New Zealand situation.

Subsequently four fishing companies jointly financed a development company [see P.M. Vela's paper on page 49] to carry out trials by arranging for three large Californian purse seiners to operate in New Zealand as New Zealand registered vessels for the 1975-76 season. These were: *Michelangelo,* 62 m (202 ft) long, with a 12.8-m (42-ft) beam, 5.4-m (17.8-ft) draught, gross weight of 967 t, cruising speed of 14.5 knots, and a carrying capacity of about 1270 t; *Kerri M,* 53 m (175 ft) long, with a 11-m (35-ft) beam, 5.5-m (18-ft) draught, gross weight of 837 t, cruising speed of 15 knots, and a carrying capacity of 740 t; and *South Pacific,* 68 m (223 ft) long, with a beam of 12.8 m (42 ft), a 5.8-m (18.7-ft) draught, gross weight of 1089 t, cruising speed of 16 knots, and a carrying capacity of 1100 t. The locally owned purse seiners *Lindberg,* 23.5 m (77 ft) long, with a 7.3-m (24-ft) beam, 3.3-m (11-ft) draught, gross weight of 159 t, cruising speed of 10.5 knots, and a carrying capacity of 90 t and *Marine Countess,* 23.5 m (77 ft) long, with a 6.7-m (22-ft) beam, 3.3-m (11-ft) draught, gross weight of 109 t, cruising speed of 11 knots, and a carrying capacity of 80 t also fished skipjack during the season.

The Fisheries Divisions of the Ministry of Agriculture and Fisheries placed observers aboard these vessels to record catch and effort data for analysis in relation to time of season, time of day, position (that is, latitude and longitude), moon phase, bottom depth, water temperature, and sea condition. In addition, a continuous log was kept of vessel movements, environmental conditions, and school sightings. Each catch was sampled and data were collected on fish length, weight, sex, gonad condition, stomach contents, and other biological factors.

Data collected on catch and effort have been combined and analysed to yield figures which describe in general terms the 1975-76 purse seine fishery for skipjack.

Definitions

In the following analyses a season day is defined as any day that a purse seiner spent in activity related to the skipjack fishery. This includes days spent fishing and searching, days in port, days spent drifting or at anchor because of poor weather or mechanical breakdown, and days spent travelling. Days fished are days on which the net was set or searching activity occurred with the aim of setting. A set is defined as any time the net was released into the water to entrap school fish and then retrieved; a successful set was one where at least 2 t of skipjack were caught. Time of day has been divided into the 6-hour periods 12 midnight to 5.59 a.m., 6.00 a.m. to 11.59 a.m., 12 noon to 5.59 p.m., and 6.00 p.m. to 11.59 p.m. Moon phase periods run from the day that a phase began to the day before the following phase began. Finally, the ranges given with mean catch effort data refer to the ranges of means of catch per unit of effort as recorded for all the purse seine vessels.

Catch and Effort

The season was about 5 months long, beginning in early November and finishing in early April. During this time the purse seine fleet worked a total of 486 season days (Fig. 1). Of these there were 224 days fished

(46%), 113 days spent in port (23%), 90 days spent travelling (19%), 51 days lost through poor weather (10%), and 8 days lost through breakdowns (2%). The large number of days spent travelling resulted mainly from the larger vessels travelling to Pago Pago in American Samoa to offload. Over half of the days spent in port were by the smaller vessels, which were often weather bound. Three-quarters of the days lost through poor weather were by *Michelangelo* and *Kerri M* between November and early January.

Catch and Effort by Month

During the 224 days fished 4715 t of skipjack were caught (Fig. 2). Quantities of fish taken by month were 18 t in November (0.4%), 307 t in December (6.5%), 1590 t in January (33.8%), 2192 t in February (46.4%), and 608 t in March (12.9%). The average catch per month was 786 t. The numbers of season days per month were 29 in November (6%), 63 in December (13%), 129 in January (26%), 145 in February (30%), 117 in March (24%), and 5 in April (1%). The average number of season days per month was 81. Mean catch per season day ranged from 0.6 t in November to a high of 15.1 t in February. Number of days fished, number of sets, and number of successful sets all followed the same pattern as number of season days, with a rapid build-up of effort through January to peak in February and drop away to April. Some 60% of days fished, 70% of sets, and 74% of successful sets were recorded during January and February. The amount of effort and size of catch per month were directly related. Mean catch per day fished ranged from 6 t in November to a high of 30 t in February. *South Pacific* registered a remarkable 59.5 t per day fished in February. Mean catch per set ranged from 3 t (November) to 19 t (January), and mean catch per successful set ranged from 3 t (November) to 31 t (February). Obviously the number of vessels fishing (one in November, two in December, five in January and February, four in March, and one in April), the relative performances of the vessels, and their activities during the month affected the averages and totals for each month. However, the effects of this fluctuating effort were overcome by calculating the various units of catch in relation to effort (Fig. 2, right-hand axis).

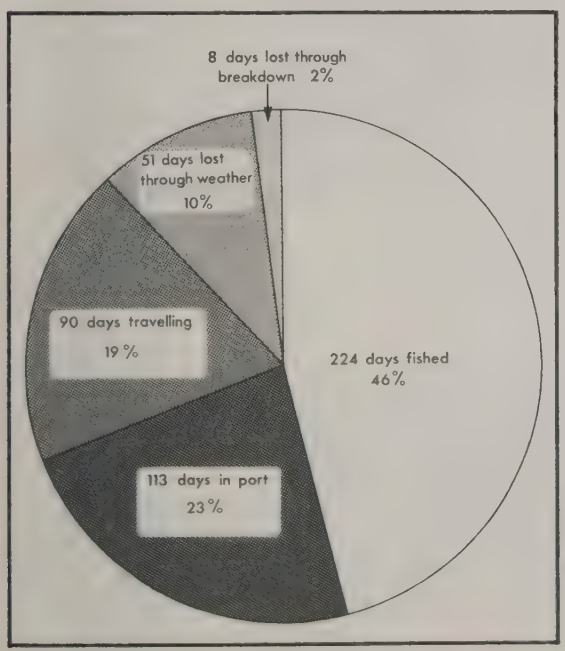
8 days lost through breakdown 2%
51 days lost through weather 10%
90 days travelling 19%
224 days fished 46%
113 days in port 23%

Fig. 1: Days fished and days lost in the 1975-76 purse seine skipjack fishery in New Zealand (total number of season days 486).

Catch and Effort by Time of Day

Purse seine catch and effort has also been analysed by time of day (Fig. 3). Over half of the skipjack (2526 t) were caught during the afternoon, one-quarter (1216 t) in the morning, and the remainder (973 t) in the evening. Effort was similarly apportioned with a little over half the sets being made in the afternoon, one-third in the morning, and the rest during the evening. However, the highest catches per set and per successful set were made in the evening (means of 23.2 t per set, 36.0 t per successful set). The means for morning were slightly below, and those for the afternoon slightly above, the season's means of 15.5 t per set and 26.2 t per successful set. No fish were caught between midnight and 6 a.m.

Catch and Effort by Moon Phase

Analysis of catch and effort in relation to moon phase showed once again that quantity of skipjack caught and amount of effort expended were directly related (Fig. 4). As examples, during full moon 25% of all sets were made (76), 39 of these were successful (22% of all successful sets) and 25% (1192 t) of the season's catch was taken; during the last quarter 8% (365 t) of the skipjack were caught in 9% of all sets (26) and 8% of successful sets (15). More than 40% of the fish were caught during the period new moon to first quarter. The greatest amount of effort for any moon phase was expended at these times, with 40% of all available new moon days fished, and 36% of all sets and 39% of the successful sets yielding over 2000 t of skipjack. The highest mean catch per set was during new moon and per successful set during full moon. It is probable that the predominance of the new moon period in the skipjack purse seine fishery was directly related to the availability of skipjack in quantity on the fishing grounds at these times. [See I. T. Clement's paper on page 36.]

Catch and Effort by Area

Seining was carried out in eight areas on the North Island coast (Fig. 5, Table 1). These were the eastern areas: A North Cape to Cavalli Island, B north-east of Great Barrier Island, C east of Mercury Bay, D Mayor Island to Waikawa Point, and E east of Gisborne, and

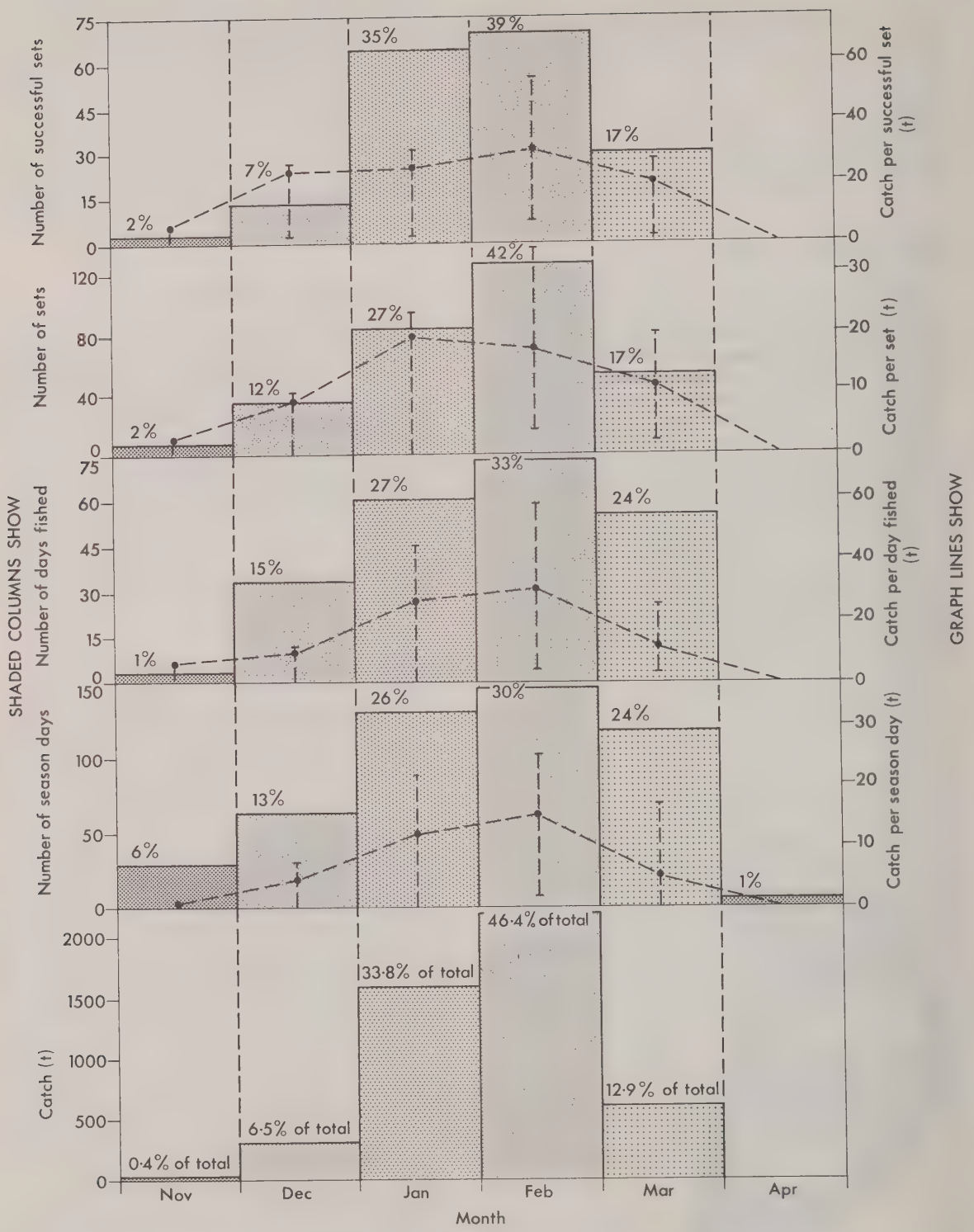

Fig. 2: Monthly catch, effort, and catch per unit of effort in the 1975-76 purse seine skipjack fishery in New Zealand.

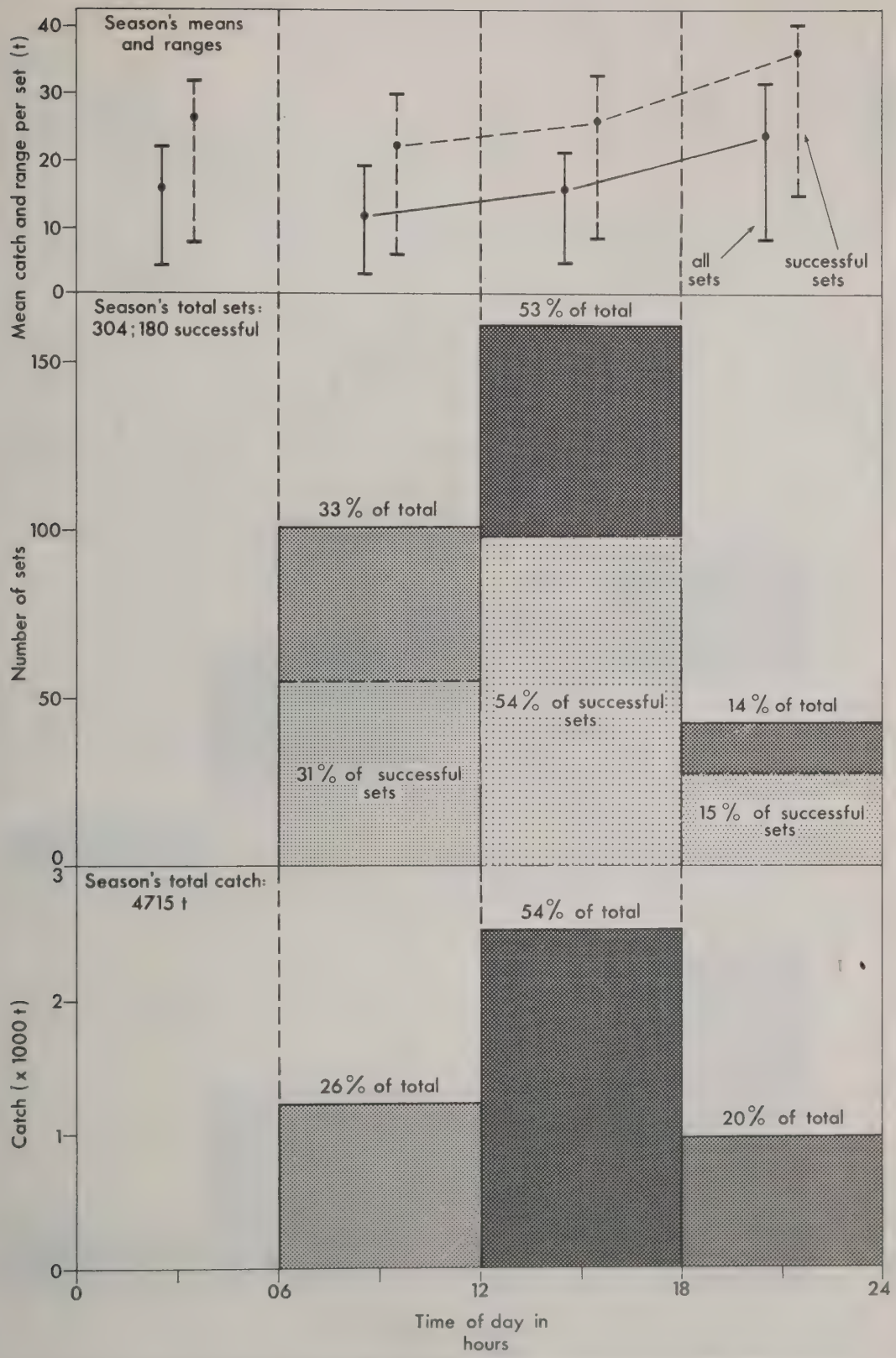

Fig. 3: Catch, effort, and catch per unit of effort by time of day in the 1975-76 purse seine skipjack fishery in New Zealand.

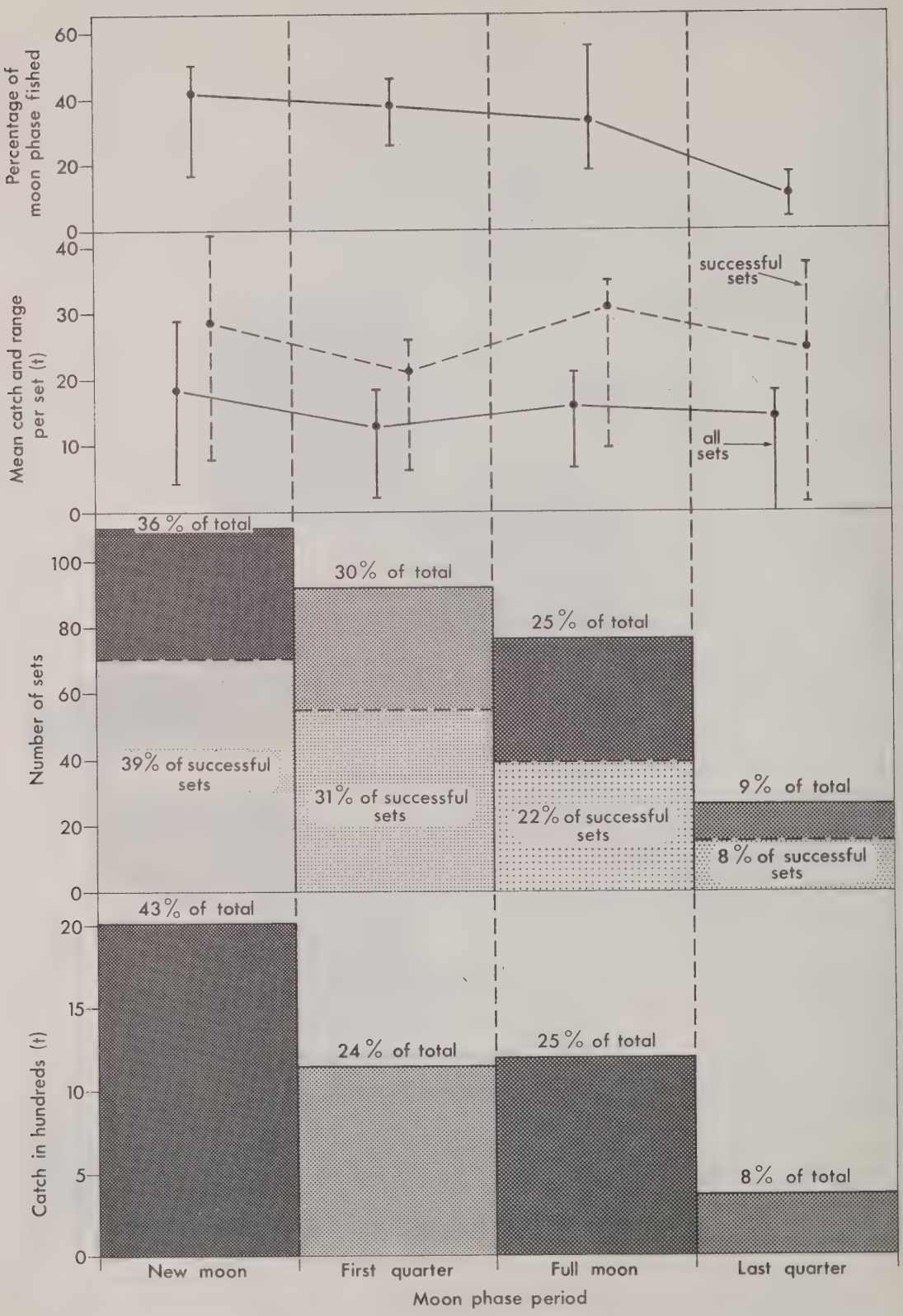

Fig. 4: Catch, effort, and catch per unit of effort by moon phase in the 1975-76 purse seine skipjack fishery in New Zealand.

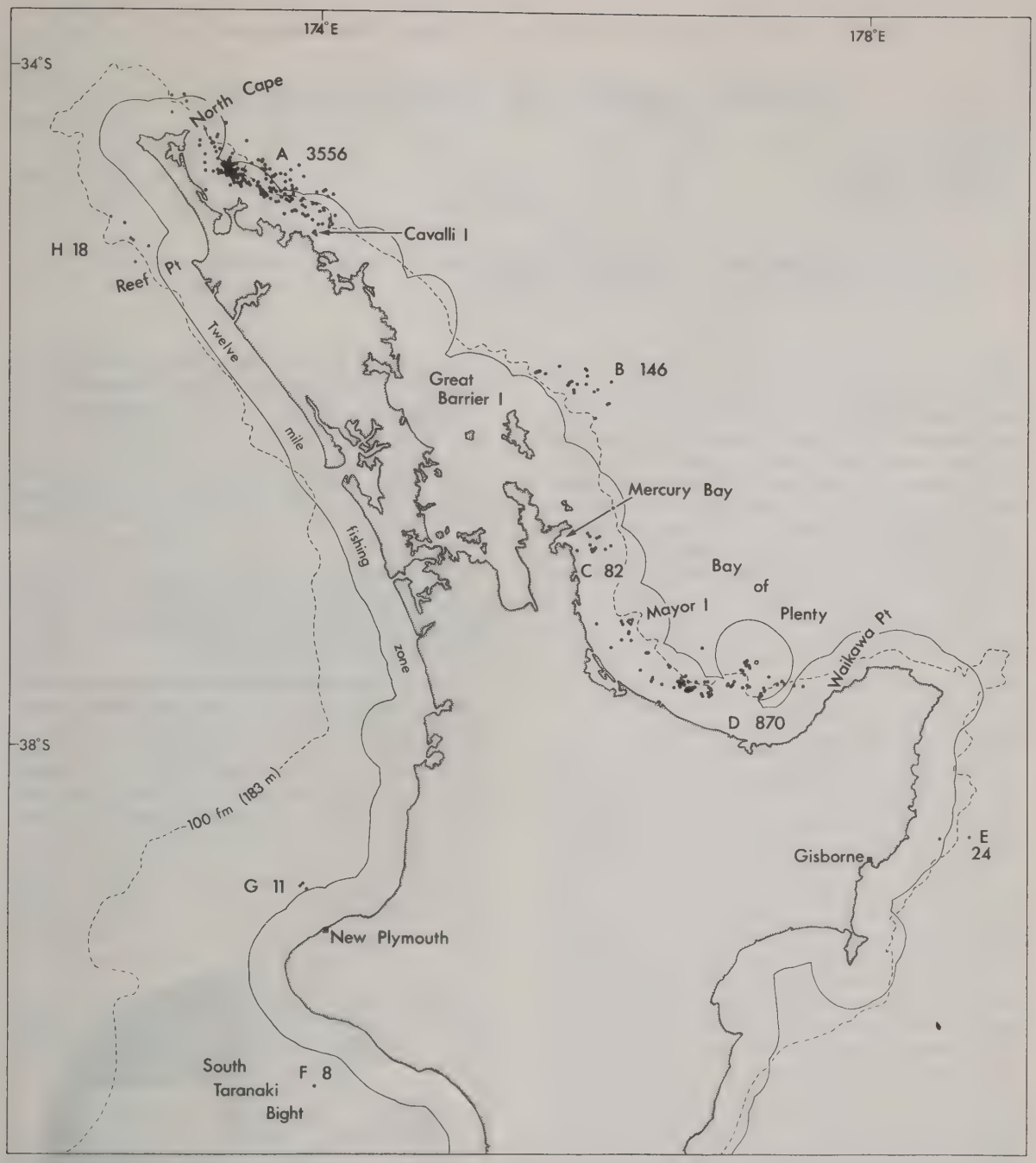

Fig. 5: Set positions and areas of fishing in the 1975-76 purse seine skipjack fishery in New Zealand.

the western areas: F in South Taranaki Bight, G west of New Plymouth, and H north-west of Reef Point. Three-quarters of all skipjack were caught in area A (3556 t), and about half of all sets (57%) and two-thirds of the successful sets (62%) were made in this area. These large amounts of catch and effort are consistent with the observation that the largest quantities of purse-seinable fish were sighted in this area during the season. Catches per set (20.6 t) and per successful set (31.7 t) were high by world standards, an indication that this area could support a viable fishery, at least for a limited number of vessels, provided that the costs of pursuing such a fishery in New Zealand are not prohibitive. About one-quarter of the fishing effort (83 sets or 27.3% of all sets, 43 successful sets or 23.9% of all successful sets) was expended in the Bay of Plenty (area D). One-fifth of the season's catch was taken here (870 t) at catch rates of 10.5 t per set and 20.2 t per successful set. Similar catch

TABLE 1: Catch and effort by area in the 1975-76 skipjack fishery in New Zealand

	Area								
	A	B	C	D	E	F	G	H	Totals
Catch (t)	3 556	146	82	870	24	8	11	18	4 715
Percentage of total catch	75.4	3.1	1.7	18.5	0.5	0.2	0.2	0.4	
Number of sets	173	22	13	83	2	1	3	7	304
Percentage of total sets	56.9	7.2	4.3	27.3	0.7	0.3	1.0	2.3	
Catch per set (t)	20.55	6.64	6.31	10.48	12.00	8.00	3.67	2.57	
Number of successful sets	112	8	10	43	2	1	1	3	180
Percentage of all successful sets	62.2	4.4	5.5	23.9	1.1	0.6	0.6	1.7	
Catch per successful set (t)	31.75	18.25	8.20	20.23	12.00	8.00	11.00	6.00	

A - North Cape to Cavalli Island
B - North-east of Great Barrier Island
C - East of Mercury Bay
D - Mayor Island to Waikawa Point
E - East of Gisborne
F - South Taranaki Bight
G - West of New Plymouth
H - North-west of Reef Point

rates were recorded in area B, where 146 t were caught. All the fish taken in area C (82 t) were taken by the smaller seiners. Skipjack schools in this area were generally small (less than 30 t) and moved about over shallow ground, factors which suited the smaller vessels. Catch rates were low, as they were in all other areas where skipjack were taken. Area H is of particular interest. Catches were made here in November 1975. A large quantity of skipjack (more than 1000 t) was present at the surface in this area during this period. However, low catch rates prevailed because schools were difficult to catch. Some were too large (over 100 t), many were too mobile, and most were too "spooky".

Analysis of Set Failures

Of the 304 sets made during the season 180 (59%) were successful and 124 (41%) unsuccessful. Analysis of the reasons for set failure yielded the results shown in Fig. 6. In 45 unsuccessful sets (36%) the school swam out under the net during pursing, and in 18 (14%) the school dived under the net before the net was completely set. In 16 (13%) of the unsuccessful sets the school swam out under the boat during pursing, in 12 (10%) the school swam out behind the boat and under the towline, in 11 (9%) the school outraced the boat while it was setting the net, in 7 (5%) the school escaped because there was a net rip, in 5 (4%) the school swam out of the net by the skiff during setting, in 4 (3%) the school escaped because the boat or skiff experienced mechanical trouble during the set, in 2 (2%) there was a net roll-up, in 2 (2%) a set was made on the wrong species, in 1 (1%) the school escaped because the bow ortza had to be released, and in another (1%) the school swam out over the corkline, which had sunk.

Summary

The 1975-76 purse seine fishery for skipjack was pursued by five vessels, which ranged from 23 to 68 m in length and 109 to 1089 t in weight.

Skipjack migrated into New Zealand waters from the north, beginning in November, and were present in purse-seinable quantities until early April.

The purse seine fleet worked 486 season days, 224 of which were spent fishing, 113 in port, 90 travelling, 51 sheltering from bad weather, and 8 making mechanical repairs.

During the 224 days fished 4715 t of skipjack were caught. More than three-quarters of this quantity was caught in January and February, with peaks in catch, effort, and catch per unit of effort in February.

Over half of the skipjack were caught in the afternoon, one-quarter in the morning, and the remainder in the evening. However, the highest catches per unit of effort were made in the evening.

Fishing was most productive in the moon phase new moon to first quarter, when 43% (over 2000 t) of the fish were caught.

Three-quarters of all skipjack (3556 t) were caught off the north-east coast between Cavalli Island and North Cape, with the balance being taken from seven other areas around the North Island.

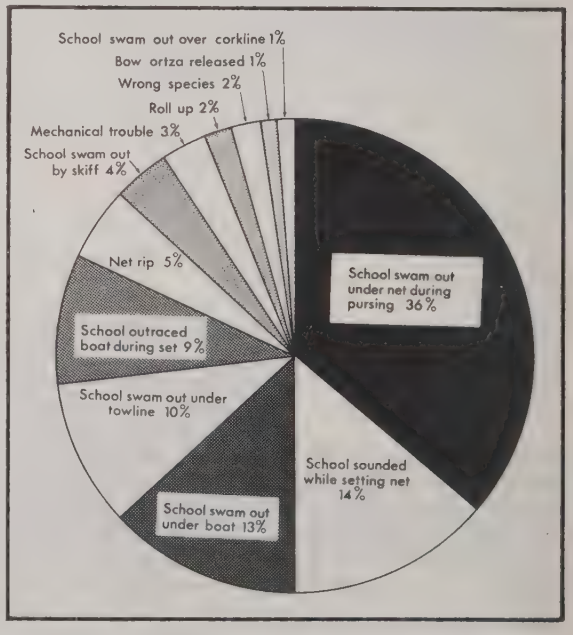
School swam out over corkline 1%
Bow ortza released 1%
Wrong species 2%
Roll up 2%
Mechanical trouble 3%
School swam out by skiff 4%
Net rip 5%
School outraced boat during set 9%
School swam out under towline 10%
School swam out under boat 13%
School sounded while setting net 14%
School swam out under net during pursing 36%

Fig. 6: Reasons for set failure in the 1975-76 purse seine skipjack fishery in New Zealand.

Aerial Spotting for Pelagic Fishes

G. R. Bell

Managing Director, Bell-Air Executive Air Travel Limited, Whakatane

My company, which was established in 1968, uses three aircraft in air charter and aerial spotting work. These are a Piper Aztec twin, a Cessna Cardinal 177 B, and a Cessna 172, the last two being single-engined. We are based in Whakatane and undertake charters to all parts of New Zealand.

My interest in aerial spotting for surface schools of fish was aroused while flying charters for the Marine Department during the 1967-68 summer. At that time Mr Don York (now of the Ministry of Agriculture and Fisheries) was studying tuna in the Bay of Plenty and it was he who provided me with much early tuition on school location, estimation of school size, and species identification. Since then I have carried out fish spotting along most of the New Zealand coastline. This has been in conjunction with various research projects (for example, Roberts 1971), the activities of research and charter vessels (*Espirito Santo* 1970-71, *W. J. Scott* 1970-71, *Paramount* 1973-75, *James Cook* 1975-76, *Michelangelo, Kerri M,* and *South Pacific* 1975-76), Government surveys (see Eggleston 1975, 1976, Habib 1975, 1976, Robertson 1975, James 1976), and the fishing activities of New Zealand vessels such as *Lindberg, Marine Countess,* and the Bay of Plenty small-boat fleet.

Contact is made with vessels through an HF Double Side Band radio set on frequencies 2045, 2456, and 2638 kHz. I also monitor the Marine Distress frequency 2182 and the Police frequency 5680.

Locating pelagic species from the air is largely a matter of experience. Schools of fish tend to form "smudges" on the surface which are characteristic for the different species. The action of schools swimming along just below the surface tends to ripple the surface water and cause these smudges. In moderate to rough seas this action tends to dampen wave action and so schools in these conditions are seen as "flat spots" or small areas of relatively calm water. Feeding schools are usually more obvious. Often accompanied by sea birds, these schools tend to break the surface of the sea in their feeding movements, at times creating a foaming appearance.

Finding particular species is also a matter of experience. For example, certain species are regularly found in particular areas at certain times of the year: trevally — Astrolabe Reef, Penguin Shoal, Three Kings Islands; kahawai — Graham, Pandora, and Ariel Banks; blue maomao — White Island, Cape Brett; jack mackerel — Penguin Shoal, Waikawa Point; English mackerel — North Cape, Graham Bank; skipjack — East Cape to North Cape on the east coast of the North Island, between the 30- and 100-fathom (55- and 183-m) depth contours.

Species identification from the air is based mainly on school colour, swimming, and schooling behaviour. Jack mackerel schools are muddy-brown, English mackerel steel-blue, blue maomao light sky-blue, trevally and kahawai green-yellow, albacore and bluefin black, yellowfin black with yellow flashes, skipjack purple-blue with silver flashes, anchovy silver, and pilchard green with silver flashes. Slow swimmers are jack mackerel, kahawai, blue maomao, anchovies, and pilchards; medium to fast swimmers are English mackerel, trevally, and the tunas.

Species can be confused in situations where the light is inadequate or where the sea is moderate to rough. Trevally and kahawai both have a sinuous body action during tail movement, but this action is more accentuated in kahawai, and trevally tend to school closer together. English mackerel and skipjack can be confused. In certain lights they have a similar colour and when disturbed they sound in a similar manner. However, skipjack are generally larger fish with distinctly bullet-shaped bodies. Albacore and bluefin tuna are often confused. However, if the fish are observed long enough, the large pectoral fins of albacore become apparent. If the fish are particularly large, they are probably bluefin, which grow to over 300 lb (136 kg). Anchovy and pilchard schools often look the same, but they can be distinguished when they sound in response to aircraft noise. On a low pass you never see individual anchovies, but you will see pilchards. If sea birds accompany fish schools, gulls and terns are usually associated with kahawai and mackerel; petrels, shearwaters, and gannets usually accompany tuna. I have tested many of my identifications through radio contact with fishing vessels and as a result have built up a number of other criteria which I can use to identify fish species from the air.

School size is usually estimated according to the species of fish. Density, surface area, and depth of school are taken into account. Often a school will cover a large surface area and at first glance appear to contain a large quantity of fish. However, these schools almost as often have no depth (no colour) or any density, as the individual distances between fish are large. My confidence in estimating school size has been built up by providing vessels such as *Lindberg*, *Marine Countess*, and the chartered seiners with estimates of schools which they have then caught and weighed. Much of my aerial spotting work now revolves around fishing and directing vessels to schools of suitable size, taking into account sea conditions, and vessel holding capacity and catching ability. This direction is often critical, particularly for the smaller seiners, as catching a school which is too large in marginal sea conditions can be disastrous.

I would like to conclude this paper with some points on the cost-effectiveness of aerial surveys. The effective spotting distance either side of an aircraft flying at an altitude of 500 to 1000 ft is 3 miles. Flying in my Piper Aztec at 155 knots, I can survey 930 square miles in an hour at a cost of $95.00, or about 10 cents per square mile. In the Cessna Cardinal, which flies at 110 knots, the figures are 660 square miles an hour at a cost of $45.00, or about 7 cents per square mile, and in the Cessna 172 flying at 95 knots, 570 square miles at $38.00, or 6.7 cents per square mile. Apart from the benefits of having an aircraft on hand to locate, identify, and estimate size of schools, and provide information necessary for successful fishing operations, the aeroplane is unsurpassed in the business of surveying large areas of water for pelagic fish species quickly and at reasonable cost.

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Some Thoughts on the Possible Development of a Skipjack Fishery in New Zealand

P. M. Vela

General Manager
New Zealand Pelagic Fisheries Development Company Limited (NZPFDC), Nelson

The subject of this paper is very broad and I will therefore touch only on areas that concern my company. The New Zealand Pelagic Fisheries Development Company is made up of Nelson Fisheries Limited and Sealord Products Limited of Nelson, Wrightson NMA of Dunedin, and Star-Kist Foods Inc. of California. I would like to review some of the points leading up to the present position of this company.

Between December 1973 and May 1975 the vessel *Paramount* conducted a survey in New Zealand waters on the pelagic fish resource. As a result of this survey it was decided that a further commercial feasibility survey was required. Therefore, the NZPFDC was established and during the last year this company has co-operated with Government in research on the skipjack resource. Many data have been collected and this information is freely available to any industry members from my company or from the Fisheries Research Division of the Ministry of Agriculture and Fisheries.

The results show that there is a skipjack resource in commercial quantities in New Zealand coastal waters for a limited season. For effective development of this surface fishery, in which the number of days fished is often restricted by weather, and the behaviour and mobility of skipjack make them difficult to locate and catch, it is necessary to have a vessel of the 1100-t class equipped with the most modern gear to allow it to operate quickly from place to place in a wide range of conditions. Such a vessel costs about $5 million and carries a net worth between $250 000 and $300 000. We are continuing to study the possibility of a skipjack fishery to determine whether we can generate the confidence necessary to justify large New Zealand investment in this fishery.

If we can generate this confidence and purchase a vessel, we would like to man it with New Zealanders as soon as possible. However, operating a large purse seiner is a highly specialised operation and so initially we would operate with an American skipper and other senior personnel and enlist the rest of the crew from New Zealand commercial fishermen. There would be a phasing-in period for New Zealand fishermen which could include practical training on United States flag vessels fishing in the east and central Pacific. This could cost from $15 000 to $20 000 for each man. However, when it is realised that only two out of five men so trained can be expected to remain in the fishery for a significant length of time, the cost is even more.

The tuna season in New Zealand is from 4 to 6 months long. We feel the resource can support a limited commercial operation. If a vessel of the 1100-t class were purchased, it would need to fish in other areas after the New Zealand season. At present the most likely fishing ground for a New Zealand flag vessel would be the eastern Pacific. The tuna fishery in this area is the most prolific and best known of all the world's tuna fisheries. Some 230 000 t of yellowfin tuna and 136 000 t of skipjack are taken in this area each year, most of this by purse seine.

There are three areas in which we would need assistance from the United States:

- in the field of technology;
- in the provision of skilled labour to instruct New Zealand fishermen;
- in market access.

With reference to market access, the United States householder consumes canned tuna worth about $1000 million annually, 50% of the entire world supply. The canned tuna industry is growing at a rate of 4% annually.

I would like to make a point about the 200-mile economic zone. I understand that we do not have the right to the fish in this zone unless we are making or can make full use of the total sustainable yield of the fish stocks within the zone. It is therefore important and

necessary for New Zealand to fish the highly migratory resource in this zone.

I realise that my company's activities have at times been the subject of misinformed criticism, and, further, I recognise that there is competition among a number of interests regarding the skipjack tuna fishery. However, my company, in conjunction with Government, has tried to focus on key issues in a research programme which has resulted in improved communication between industry and Government and indicated direction for the future development of a New Zealand purse seine skipjack fishery.

In conclusion I would like to recommend that industry and Government try to establish:

- means of funding exploratory fishing;
- means of evaluating the resource both now and in the future;
- means for harvesting, processing, canning, and marketing under-utilised tunas and closely related species, for example, English mackerel;
- tax incentives and other financial encouragement for the exploration and development of this fishery.

Sanford's Outlook on the Skipjack Tuna Fishery

N. L. Mills

General Manager, Sanford Limited, Auckland and Tauranga

I have been asked to talk to you about how my company sees the skipjack fishery in New Zealand. I must first congratulate the members of the Fisheries Research Division on their efforts in researching skipjack. However, they will agree that there are a lot of gaps to fill yet. Second, I would like to state now that from a New Zealand fishing company's point of view, it is uneconomic to be interested only in the skipjack fishery. The main reason for this is that the season is so short that it is necessary to use the vessel in other fisheries during the 8 to 9 months of the off season. For this reason, I hope you will excuse me if all my remarks are not aimed directly at skipjack, but I can assure you they will all refer to the purse seining of pelagic species.

I would first like to give you some background on how Sanford's became involved in purse seining for pelagic fish. In 1964 we were considering building a 70-ft (21-m) trawler and, just before finalising the construction, we decided to set the vessel out in such a way that purse seining trials could be carried out to test this method for harvesting the surface schooling fish which we knew abounded in the Bay of Plenty, close to our factory. As the construction proceeded the Fishing Industry Board became involved in what later became known as the Japanese fishing demonstrations, and in 1965 our vessel *Valkyrie* was used for the purse seining section of those demonstrations.

After the demonstrations we employed a Canadian skipper and continued operating the vessel as a purse seiner. Unfortunately, we had many major breakdowns, first with the gearbox and later in the main engine. The costs to the company for these experiments were such that the rest of our business could not provide the necessary cash and, as the Government at the time refused to assist us, we were forced to change the vessel back to trawling. You may be interested to know that the winch and a lot of other gear used for these trials are now being used very successfully on the vessel *Lindberg*.

Since those trials we have been well aware of the potential for purse seining in the Bay of Plenty, but our financial position has been such that we could not take the large risk involved until 1974, when we commissioned the fishing vessel *Lindberg*. The building of a specialist vessel to prove an unknown fishery at twice the cost of a trawler to fish a proven profitable fishery shows the faith that the executive staff and directors of Sanford Ltd had in pelagic fishing. At the time of planning this vessel it was clear that to use a vessel which could carry much over 100 t in the New Zealand fishery would put such pressure on the factory that it would be necessary to fish only for skipjack, and in the off season fish the coast of some foreign nation. I will mention more on this aspect later.

A vessel with a capacity of 100 t seemed the ideal size, because when trevally, mackerel, and kahawai were caught they could easily be handled by our existing factory in conjunction with our normal trawl production. In practice, we have found that this is conservative, as we can handle quantities about 50% above that quite satisfactorily.

However, we still believe that it is far better to have three 100-t capacity vessels than one 300-t vessel, as this would spread the flow of fish into the factory. Moreover, with three vessels, overhauls and breakdowns would not create such a shortage of product. *Lindberg* has proved herself and is now contributing to the profits of the company. Since 1 September 1975 she has landed 1250 t of fish and as it has been possible to sell all this on a buoyant export market, she has earned in excess of $300 000 in foreign exchange for New Zealand in 10 months. It is unreasonable to assume that, with fish other than skipjack, these prices could have been achieved had we caught, say, 10 times the quantity, as that would surely have depressed the existing markets. However, we are confident that these markets will expand as we increase our fishing efforts.

With 2 months' fishing left to the end of our financial year and the likelihood of the current school fish remaining on the surface until September, I believe we will easily reach our budgeted 1500 t.

Lindberg is a total New Zealand venture. The vessel was designed, built, and commissioned in New Zealand and is manned by New Zealanders, and because it was our first, obviously we made mistakes. Too much emphasis was placed on the fact that if not successful we would need to convert to trawling, and for this reason carrying ability was neglected. The style of the vessel,

the layout, machinery, and refrigeration are well up to the standard we wanted, but because she settles too low in the water aft when fully loaded, she is unable to travel long distances in rough conditions with a full load. We are now investigating modifications that we believe will overcome this. These factors will be foremost in our minds when our next vessel is commissioned.

I have brought you up to date regarding Sanford's achievements and I would now like to follow with how we view Government's efforts and what we intend to do in the future.

We have heard what Government has done. Their research effort has been good. I would like to comment on what Government has not done and perhaps bring about some changes in Government attitudes. In view of our belief that in New Zealand it is not economic to fish solely for skipjack, we are disappointed that almost all Government research on actual fishing has been aimed at skipjack. The original programme asked for by the Fisheries Development Council of the NDC was for experimental fishing by the purse seine method for pelagic fish. I emphasise the words pelagic fish. The first step was the *Paramount* surveys and over an 18-month period a negligible amount of effort was spent on species other than skipjack, and then the powers-that-be became sidetracked until all the time and effort was spent on skipjack. At no stage did *Paramount* do any winter fishing in spite of the results of feasibility studies on *Lindberg*, which were given to the Ministry of Agriculture and Fisheries and which clearly showed that we depended on winter fishing to make a profit. My company asked for Government assistance to do a winter survey with *Lindberg* in 1975. This was flatly refused by Mr Cunningham of the Ministry; to quote his letter: "Available information has not shown that fishing for pelagic species over the winter period would be a viable proposition."

I think results show not only that a survey was required, but also that a winter fishery does exist. *Lindberg* has landed 350 t in the last 3 weeks, 100 t last Sunday, and a further 40 t the next day before she was forced in by the weather. I think current landings of *Lindberg* and *Marine Countess* again show that fish other than skipjack have been completely ignored by Government in the catching research programme. Moreover, it is quite clear that Government is prepared to pay a foreign company to research one species — skipjack — in which that company is vitally interested for its own cannery and then completely refuse assistance to a wholly New Zealand-owned venture.

I would also like to make it known that we were refused assistance towards the cost of bringing an American skipper and deck boss to New Zealand to do the initial fishing and crew training for *Lindberg*. I don't really know, but I believe no assistance has been given to any other New Zealand company that has invested high-risk capital in purse seining. New Zealanders investing in this new fishery are not getting fair treatment, especially when last season we had to compete on unfair terms with three chartered super seiners which were given legal dispensations that are not available to New Zealand vessels or crews. These vessels took fish with a selling price of about $3 million out of New Zealand and this country did not even get the benefit of the overseas currency. Moreover, when the chartered vessels left New Zealand they took away the assets and expertise needed by the two New Zealand companies operating seiners, leaving them to struggle along on their own. Thus after giving away $3 million worth of fish we are no further ahead than after the *Paramount* surveys. This is surely a very expensive way to get New Zealand scientists to the fishing ground.

I mentioned competing on unfair terms with these charter vessels. I would like to expand on this. The two New Zealand seiners and the multitude of small New Zealand jig-fishing vessels are forced to land their fish in New Zealand and thus be involved in the costs of unloading, storage, transport to export, and the very high traditional freight to overseas markets. Let us look at what these costs would amount to on the 5000 t caught by the United States charter vessels:

	cents per lb
Unloading and transport to freezer	1.25
Freezer storage one month	1.00
Transport from freezer to ship, wharfage, etc.	1.50
	3.75

This amounts to about $75 a tonne or about $375 000 on the total. A further $1.5 million would have been added to costs for sea freight to overseas markets. Thus the return to New Zealand interests would have been considerably less than the total value of the product.

If the Government is naive enough to allow foreign charter vessels to work our coast inside the 12-mile limit in the future, in direct competition with wholly New Zealand-owned ventures, all I can say is that it confirms the point I made earlier that they would rather assist foreigners than New Zealanders who have taken a very large financial risk. It would be even more unfair because the large multi-national company H. J. Heinz, which operates these charter vessels, has tariff protection against tuna processed in the country whose coastal waters they are fishing.

I stated earlier that we believe the best size of vessel for New Zealand conditions is in the 100- to 140-t capacity class, as this amount could easily be processed and handled at one time by our existing facilities. To operate larger vessels would mean fishing them in the coastal waters of other nations during the off season in New Zealand. This might be difficult considering the extremely protective fisheries policies being adopted by most other countries, including the United States. Vessels of 100 to 140 t can comfortably handle 50-t schools, and most schools are under this size. The use of super seiners to test the New Zealand fishery is ridiculous when it is clear that New Zealand does not

need vessels of that size and cost to establish a successful purse seine fishery. I do hope that current Government thinking is to retain the present fishery for New Zealanders and not perpetrate a policy of giving away millions of dollars worth of fish from inside our 12-mile limit under the guise of proving a fishery. As a New Zealander, I would object strongly to that.

Let us now look at Sanford's plans for expanding our involvement in skipjack and in pelagic fishing generally. First, we are most anxious to add to the catching ability of *Lindberg*. I have mentioned that we are investigating modifications which will increase the carrying capacity of this vessel. Second, we are negotiating to supplement *Lindberg's* catching effort in one of three ways:

- Purchase of a French-built purse seine vessel of 110 ft (34 m) with a carrying capacity of 140 t.
- Purchase of two overseas seiners with carrying capacity of 100 t each. These vessels are of proven design and are of similar size to *Lindberg*.

(Both of these propositions would see us with either one or two additional vessels in the skipjack fishery next season.)

- Construction of a seine vessel of 140-t carrying capacity, on which we have had preliminary discussions with a New Zealand shipyard. For vessels of this size New Zealand shipyards are competitive with overseas yards. Unlike that of *Lindberg*, the final design of this vessel would probably come from overseas. If we proceed with this option, it is obvious that the vessel could not be in the skipjack fishery this year.

It is too soon to know which of these courses we will follow.

With regard to shore plant expansion, we have started on buildings for a fish-meal plant which will be operative before the end of the year. It is not our intention to use this plant for whole fish for economic reasons. We have sufficient land adjacent to our Tauranga plant for a cannery and it is in our forward planning to build such an installation to process skipjack, albacore, mackerel, and kahawai and also other products until the fish volume available is sufficient to sustain the plant full time.

We are exploring the processing of skipjack to reduce the volume and so alleviate the problem of high refrigerated freight costs to foreign markets. This is a very technical process and may need overseas expertise to develop. New Zealanders will be employed in this first, as we see definite advantages in remaining a wholly New Zealand-owned company. For trevally and mackerel we believe a large frozen fish market exists at prices in excess of cannery value.

Regarding costs in this expansion, the 140-t capacity seiner, either new or secondhand, would be about $1 million, allowing for delivery costs and necessary modifications if the vessel is secondhand. The two smaller seiners would cost about $1.25 million and the cannery $1.5 to $2 million. This adds up to a total investment of about $5 million. My company has the ability and faith to fund a development of this size, and I know we have the fishermen, shore staff, and executives to see such a project through to a profitable conclusion.

However, I am most concerned that Government's attitude appears to be to support foreign vessels fishing inside our 12-mile limit and creating unfair competition for New Zealand fishermen. If this is to continue, perhaps we should follow the advice of the President of the New Zealand Manufacturers' Federation, who noted that better returns appear to accrue from strip clubs and massage parlours than from traditional industry investment. As manager of a New Zealand company which has for many years researched and invested large sums of high-risk capital in pelagic fishing, I feel we were sold out by Government's allowing United States seiners inside the 12-mile limit last season.

Wattie's Interest in Tuna and Plans for Development

G. J. Wattie

Managing Director, Wattie Industries Limited, Gisborne and Hastings

First I should like to cover some of the history of our association with tuna that has taken place over the past 15 years or so.

We have been working to establish tuna fishing and canning since 1958, when our interest was aroused by the visit of a Japanese tuna boat to Gisborne. Many of our facilities are adaptable for tuna canning and this encouraged us to try to obtain fish from the visiting vessel for a trial pack. At that stage of our development at Gisborne we were already processing some trawl-caught fish and could see much greater opportunities for volume canning with tuna for New Zealand and possibly export markets.

Our efforts to obtain fish from the Japanese were stopped by Government, who advised that there is a regulation preventing the landing of fish from foreign vessels. The Seamen's Union was also opposed to the proposal.

I personally believe that if we could have processed then, with careful Government control and levies on landings, a very respectable New Zealand tuna fishing and canning industry could have been established by today.

Having been prevented by law from obtaining access to the tuna, we felt that, as the fish were around our coast, we should try to catch them to see if an economic industry could be established. About 1960 we purchased a vessel and fitted it out for trolling and pole fishing with the aid of a United States tuna fisherman. After two or three seasons and not enough success to prove economic soundness, our United States fisherman left and "Blondie" Madsen took over as skipper of the vessel. We tried trawling in winter and tuna fishing in summer, but still could not prove the fishing to be economical. However, we did show, and Government trials and other fishermen proved, that trolling by smaller boats and crews could be successful.

We spent a great deal of time and money in those early years and were beginning to doubt if New Zealand vessels could find a method of tuna fishing to suit our conditions. During the 1960s there was a demonstration of Japanese purse seining out of Tauranga. This method of fishing for other pelagic fish besides tuna impressed us and so we began to use it. Here again, we were breaking new ground and it has taken some years to reach the stage where we are now confident of purse seining tuna successfully. "Blondie" Madsen can tell you of the many tribulations and frustrations we have experienced in reaching our present position. In recent years we have concentrated on purse seining mackerel, kahawai, and trevally, which we wanted for processing, and these fish were more suitable for the equipment we had on our vessel.

This year, for the first time, we have made a positive approach to purse seining tuna and have ignored other pelagic species. We met with some success and any losses can be attributed to the fact that the vessel is without refrigeration facilities and therefore had to return to port constantly to unload the tuna for processing. We consider that the size of vessel which we have at present is about ideal for New Zealand tuna fishing conditions, bearing in mind that we want a year-round operation for our vessel and not sole restriction to tuna. We are planning to increase the length of our boat by inserting a section amidships, and we will install a brine freezing system.

However, we are now fitted for tuna and last season proved we were capable of purse seining skipjack, and we look forward to an even better season next year with the extra capacity we plan to build into our vessel.

We must of course mention here the work of the Whakatane fishermen, in particular John Plews. No doubt most will have read in the June issue of *Commercial Fishing* the comment by Mr Dave Jamieson, entitled " 'Shabby treatment' on the tuna issue", which puts his views on the way the Whakatane fishermen have been treated over the years regarding the prices paid for tuna. We can pay anything we like for tuna, but unless the customer buys it, we can make no profit on a warehouse full of canned tuna, as we must compete with imported stocks and other alternatives that are available to the customer. Because of the understanding that has been built up over the years with the Whakatane fishermen, we have persevered in obtaining supplies from this area, and difficulties associated with transport and now ice supplies are problems for our company. Last season it cost us 7 cents a pound to bring tuna from Whakatane to

the Gisborne factory. This is not all transport cost, but a large part of it is, and the rest is related to ensuring a satisfactory supply of ice both to the boats and for transport.

Our shore processing plant has recently been improved for tuna canning and further developments to this are planned.

One of the problems that we will be facing in the near future is the expected Government regulations regarding the licensing of tuna-processing factories, particularly with regard to export licences. We are in a unique situation in that we are the only factory which is processing frozen fish, canned fish, fish-based pet foods, and fish meal, and because of this combination regulations will affect us considerably and necessitate a major re-layout of our fish-processing operations without adding any value to the products produced from these areas. The regulations, as they stand at present, will divert capital into meeting new requirements rather than allow us to develop our industry.

After many years of trying to establish tuna as a worthwhile catch for processing in New Zealand we can feel that success is close. This is gratifying after all the time, effort, and money that have been spent over the years. However, we are now concerned to know what the rules are going to be governing foreign vessels fishing in our waters. Will they be permitted to land fish here? The answer to this must affect the pace of our development and plans for the future.

It would be very easy for Government to allow overseas interests to move into the New Zealand area and take advantage of the situation. Large foreign vessels with shore facilities could soon circumvent all the money and time we have spent so far.

In many areas of development, and fishing is certainly no exception, New Zealand does not have the capital resources for financing operations requiring large capital investment. Equally important, we do not have the experienced manpower resources, and one is no good without the other. Our progress is controlled by these factors and can develop steadily if profit can be demonstrated to both labour and capital.

No doubt development of tuna fishing could be faster if we were prepared to accept foreign vessels and crews operating from New Zealand. However, we cannot agree with this approach without safeguards for New Zealand fishing interests. Perhaps there is some merit in controlled fishing by foreign vessels, when the 200-mile zone becomes effective, but this should be in defined areas and with fishing activities that do not affect the development of New Zealand's own fishing industry.

We have a great deal at stake in tuna development and must know what the rules are going to be covering the fishing activities of foreign purse seiners in the skipjack fishery.

Summary

We have the canning experience and many of the facilities already available to handle large quantities of tuna.

We estimate that the New Zealand market should require 1000 t or more a year when we have the stock to promote the product. Export markets have yet to be assessed and will be influenced by the price we offer at the time.

We consider that purse seining for skipjack should be by New Zealand vessels only. If foreign vessels are allowed to fish in our waters and land their catches, we must accept that this principle should apply to all types of New Zealand fishing operations.

Now that we have the experience to purse seine skipjack, with continued assistance by the Ministry of Agriculture and Fisheries and encouragement with finance from Government, the industry should soon become well established.

It would be a tragedy if, after all that has been accomplished, we are forced at this critical stage to stop short of our goal.

Tuna: The Problems for Further Processing in New Zealand

C. C. Hufflett

Managing Director, Sealord Products Limited, Nelson

The desire of New Zealand to develop a secondary industry based on a primary industry resource is well known. For many years we have been shipping to world markets whole carcasses of meat which, save for their initial killing and cleaning, have undergone no processing whatsoever. Much of our timber leaves the country in the form of logs and only recently have attempts been made to supply timber overseas as a chipped product.

Further processing in New Zealand of any primary resource is intended to give added value and therefore increased export earnings for New Zealand. Furthermore, in view of our distance from world markets, additional processing (as with tuna) reduces the wasteful use of expensive shipping space.

Our Involvement

Sealord's involvement in the skipjack fishery is focused on our 25% shareholding in the NZPFDC. In addition to this we catch small quantities of skipjack from our teichi nets at Whitianga, but these catches have never exceeded 15 t per year. We have a particular interest in canning albacore from the west coast of the South Island specifically for the Japanese market. Our overall interest in the fishing industry relates to processing and we lay claim to being New Zealand's largest processer of fish products; that is, we cook, can, breadcrumb, smoke, and dehydrate more fish than any other New Zealand organisation. Obviously, therefore, we have investigated the possibility of canning skipjack in the future.

Why Can?

The overseas market requires it this way, with the exception of tuna caught for the Japanese sashimi market. Most of the tuna caught in the world today is canned for the United States market.

In the same way that canning pineapple alters its taste, tuna "improves" in the canning process.

New Zealand Fish Canning

Though canneries in New Zealand specialising in the handling of agricultural products or canning of beer are among the most sophisticated in the world, the fish canneries are by no means as well advanced. Where the canning of fish is associated as a section of a larger processing complex, invariably equipment used today is older and operates at slower speeds.

In New Zealand most fish canned is intended for further cooking by the housewife after it is opened. This is a local feature, and the traditional New Zealand fish pie still uses most of our canned fish production.

The only "salad" canned fish are tuna produced by Wattie's in Gisborne and my own company's Pacific mackerel. By salad fish I mean a product which can be eaten directly from the can, either as a sandwich spread or with a salad for a summer meal.

New Zealanders do not understand tuna and certainly will not pay the price difference between white meat (albacore) and light meat (skipjack).

Any development of the tuna industry for the local market will require a huge promotional programme. The object would be to replace the current imports of canned salmon with a locally produced New Zealand tuna. Australia in recent years has developed such a market and tuna now is almost as well accepted there as in the United States.

Cannery Development in New Zealand

I doubt if there will ever be the development of a large-scale tuna cannery such as is seen in the United States. Composite units which rely on tuna as a seasonal adjunct to their operation will be established. Tuna canneries throughout the world are based around the location of fishing. Thus we have specialised canneries based at such places as Pago Pago and Terminal Island in the United States. Recently there has been the estab-

lishment in Fiji of a Japanese tuna cannery and can-making plant.

The associated products to be produced in New Zealand could include both Pacific mackerel and jack mackerel, but the market is weak and low priced. Japan does export, however, between $9 and $11 million worth of canned mackerel to the Pacific islands each year. This is a sufficiently large market within ready access of New Zealand to provide for off-season production in a tuna cannery.

As is already happening in New Zealand, there are small "hand-packed" lines operating which produce various grades of canned tuna. These lines are not economic in the international market, but do supply the needs of a local consumer.

Association with Catching

It is important for the fisherman to realise that if he is setting himself up as a catcher of tuna, he must base himself near the cannery or within ready access to it. Unfortunately in developing a fishery of this nature, small landings are likely to occur at various shore locations far removed from the processing complex. Consequently freight and storage constitute a high proportion of the landed cost of that fish into the cannery. This has the immediate effect of lowering the price to the fisherman. In the stages of developing a new fishery there is obvious restraint provided by this.

Any tuna fisherman basing himself in an outport with difficult transport access must expect a lower price for his fish.

This business is totally unlike previous New Zealand fishing experience where the small operator can catch, say, up to 10 boxes of snapper and sell to the local fish and chip shop. There is no ready market of any consequence for tuna other than through a major processing complex. This point must be realised by the individual fisherman before he locates himself in an impractical fishing port. The short fishing season requires a large freezing capacity.

The logical development of the catching sector has been shown at Greymouth, where a comparatively large handling base has been established. The failure of the albacore fishery this year on the west coast of the South Island does, however, serve as a warning and illustrates the difficulty of developing an in-shore pelagic fishery.

Restraints on Development

Prove the resource. The resource must be proven first and this was the prime object of the chartered super seiners last year. It should be emphasised that these vessels during last season caught 5000 t as opposed to the total New Zealand catch of only 200 t. On the New Zealand figures alone, there would never be the development of a New Zealand tuna cannery. There has been only one fishing season of significance and this provides insufficient information for further development into processing. A sustained fishing programme on the same scale as the chartered American ships last year would need to continue for a further 3 years before industry could be expected to invest heavily in the processing sector.

Local market. There is virtually no local market for this product and our population size is not sufficient to provide a large development in this sector. Overseas markets must be secured, and it should be realised that countries such as the United States who are the prime users of this product already have their own canneries. There can be no immediate desire by the consuming nations to purchase tuna in the canned form when they already have the equipment and labour employed in this industry.

Government buying support. None of the Government defence agency orders or the Stores Board or hospital contracts include any New Zealand canned fish. When these agencies advertise their annual requirements by tender, they request only imported items such as herrings in tomato sauce and salmon.

Imports of fish. The heavy imports of canned salmon a few years ago certainly dealt the death blow to the attempts of some small tuna canning processers to develop a New Zealand market. However, perhaps the industry should not complain too quickly about the imports of canned fish, but should concentrate on obtaining liberalisation on equipment imports and the purchase of vessels overseas.

Support Needed

Catching sector. Those companies concentrating on larger vessels in the 200-t (100-ft or 30-m) class do need to have access to world markets for the purchase of vessels. These ships should be permitted duty-free entry and the purchase of nearly new vessels should also be approved.

Government buying support. The restraints placed by Government agencies not purchasing New Zealand fish have already been explained. In addition to this, Government should include an allocation of, say, $5 million a year of its foreign aid programme to be provided in the form of canned fish. This would provide a sufficiently large "captive" market to establish fish canning in this country once and for all.

Depreciation. Depreciation allowances can take many forms, but should certainly provide an inducement in the form of taxation savings for companies to

invest the large capital required for the development of this industry.

Export market incentive. A special export market incentive should be established to provide grants in developing overseas markets.

Finance. Finance should be available on similar terms for both the processing and catching sectors to that provided for the agricultural industry. Terms up to 20 years should be included to minimise the initial capital outlay.

Conclusion

I do not see the development in New Zealand of tuna canneries as they exist in the United States for many years yet, if ever, but there is no reason why an intermediate sized tuna cannery such as now exists in Australia could not be established within the next 3 years. Much work has been done by the Ministry of Agriculture and Fisheries and various commercial concerns over the last few years and the tuna industry requires now just that final impetus to get it established as one of New Zealand's major export earners.

Summary of Discussions and Comments

Because the conference was designed as a forum for the exchange of views and information rather than for the presentation of formal papers there was no prior intention to publish a detailed account of the meeting. However, in view of the response obtained and the requests for all data to be made readily available, the contributions have been condensed with the willing co-operation of the authors and assembled in this publication.

As expected among any group of fishermen or scientists the discussions of some aspects of the work and the fishery were protracted and detailed. Thus verbatim publication of them would have been cumbersome. Instead, for the sake of brevity and so that the account can be made available as quickly as possible, various points from discussions and highlights from papers have been summarised in this concluding section.

Skipjack Biology

Despite the comments made about the high oxygen and temperature requirements of the fish there were several references to skipjack over-wintering in New Zealand waters and growing to a large size (16 kg). This suggests that some may be tolerant of a wider range of environmental conditions than was previously supposed. Australian experience with their tuna also seems to support this view. However, it is important to note that relatively small numbers of fish do over-winter in New Zealand compared with the vast majority which are summer visitors.

Though skipjack taken by purse seine appear to feed predominantly on euphausiids they will also take bait-fish, which suggests that pole and seine-caught fish may exhibit different feeding behaviours and therefore be susceptible to different catching techniques. It was suggested that the size of the bait or its behaviour can be of considerable importance to successful fishing. Opinions differed, but it was established that once the fish were in a feeding frenzy any bait would catch them.

It was also stated that there was some difference in the sizes of fish taken by purse seines and lines and it may be that when the large fish are dispersed they are more readily taken by the latter method.

Periodicity of schooling patterns observed in the course of the purse seine surveys is unexplained, but may be associated with the swarming of suitable food organisms, which in turn may be influenced by moon phase or weather patterns or both of these.

A major point of significance is that the modal size of fish taken off the coast is similar from year to year. This is clear evidence that most of the fish which migrate through New Zealand waters do so only once in their lifetime and if not then taken they are lost to the local fleet.

There is an extensive Pacific fishery, but the status of separate stocks of fish which may inhabit the eastern, central, and western tropical Pacific is still unclear. However, if the skipjack resource as a whole is to be properly managed internationally the existence of one or several distinct stocks must be clearly established. This is a study in which we hope to collaborate with other agencies.

One area of concern is the great variability in abundance of the fish from year to year. The factors affecting their spawning success and migratory behaviour are not understood, so that it is not yet possible to predict how good any given season will be. This suggests the need to employ only modest numbers of fishing vessels until a background of suitable statistics has been obtained which will indicate the catch levels that can be expected.

Management Considerations

It was stressed on several occasions that for the purposes of fishery regulations the charter of foreign vessels must be approved by the Minister of Agriculture and Fisheries, they must be registered as New Zealand vessels for the period of the charter, and must abide by the local survey and manning requirements. Some special dispensations may be given where appropriate, but only in a manner similar to those given to local vessels. The charter of the Californian seiners by NZPFDC was fundamentally the same as charters of foreign vessels made in the past by other companies, such as those which surveyed for southern bluefin tuna and for southern spider crabs. The difference is that the last two proved unprofitable, but the first shows promise.

Under the Marine Mammals Act, and to ensure entry of locally caught tunas into the United States market, special provision has to be made to avoid killing or capturing dolphins and porpoises. These mammals generally do not school with skipjack and none has been taken by any of the purse seiners during three seasons of operation.

In terms of the Law of the Sea Conference, and with special reference to proposed regulations governing highly migratory species such as tuna, it is evident that some international body will be needed to regulate

fishing and manage the skipjack resources of the region. To safeguard our interests it would be essential for us to be represented on such a body, but we can demand this as of right only if we are seen to be engaged in, and to have a substantial investment in, the fishery.

Small-boat Fishing

There is undoubtedly a future for small-boat fishing, probably based on pole and line fishing with live bait rather than on gill nets, though these have been used successfully. Storage of fish in small boats presents a problem if they are to be landed in good condition. There is, therefore, a need for good on-shore facilities, particularly ice plants in some of the smaller ports with difficult access for large vessels.

The suitability of lures was discussed and it was pointed out that different colours and sizes should be used in waters of different colour and clarity and in relation to cloud cover.

The use of acoustic lures could assist fishermen, particularly those working from small craft, and there is some evidence to show that subsurface fish can readily be detected with echo sounders.

The great importance of finding and storing suitable live-bait species was stressed by several speakers, and there is obviously need for study of the biology, behaviour, methods of catching, and methods of holding live bait, for which a separate fishery may well be justified. One existing technique, the use of box nets, may have some part to play, as several bait species are caught and remain alive in these nets. However, it would be necessary to modify the design of net and the size of mesh.

The evidence for the occurrence of bait schools in northern South Island waters augurs well for the accumulation of stocks of bait-fish, but the need not only for suitable species, but suitable fish sizes, was stressed. It was also pointed out that for the sake of handling and holding such fish in good condition it is most important to make numerous catches of small (1-t) schools rather than attempt to catch small numbers of big schools. Fish in small schools can be handled more safely and quickly and with less mortality.

Despite the emphasis on live bait some fishermen were satisfied that dead bait could be used equally effectively.

Fears were expressed by some of the small-boat fishermen that large vessels could overexploit the skipjack resource, but these fears were countered by evidence which suggested that small and large vessels exploit different sections of the stock and that purse seining is not profitable or even practicable on small schools close to shore. Moreover, the fact that most of the fish visit New Zealand waters only once in their lifetime means that they are unlikely to be overfished by the New Zealand fleet, but intensified effort by other countries in the tropical Pacific could influence total numbers which migrate to our waters.

Low prices paid to local fishermen were a source of concern, but the transport and marketing problems of processing plants remote from small ports were explained by processers.

The success of a pole and line vessel in February confirmed the observations from the large vessels that the peak of the season can be expected during that month, but the economic success of this type of fishing is entirely dependent on a regular supply of suitable bait.

Purse Seine Surveys

The use of large vessels for bulk catching a single species was criticised. Many fishermen believed it was important for seiners to be versatile and able to take other pelagic species such as trevally and horse mackerel during the off season for skipjack. It was explained that large vessels were used because it was felt to be essential to prove the resource by demonstrating that big quantities of skipjack could be caught. Furthermore, they are specially designed for the job, they can catch and hold large quantities of fish, and they have expert crews who are used to working as a team, which is essential, for purse seining is an "art".

Although the catches were good by overseas standards, much fishing time was lost because of the need to transport the fish from New Zealand in the fishing vessels. Offloading in New Zealand could save fishing time if speed of handling is sufficiently high. Alternatively, planned unloading in American Samoan canneries during the last quarter of the moon could result in the minimum loss of good fishing time, if last season's observations are typical of the cyclic nature of the fishery.

Purse-seinable skipjack are present in New Zealand coastal waters only from November to March and specialist tuna seiners would have to fish elsewhere for the rest of the year. In June the research vessel *James Cook* investigated the possibility of a winter fishery around the Kermadec Islands and trolled a few skipjack, but saw no schools. Skipjack food organisms were scarce and this, together with the extremely clear water and lack of thermocline, indicates that any winter fishing would be beyond our 200-mile limit.

The most significant feature of the surveys so far has been that the fish occur predominantly on the east and north-east coast of the North Island and that they are most readily caught within the 12-mile limit. This suggests that New Zealand vessels would have virtually the exclusive right to take them. Surveys both at sea and from the air have shown that schools vary considerably in size and distribution, but schools in excess of 200 t are not uncommon.

The value of these surveys in showing the scale of the resource was emphasised and so, too, was the very great importance of aimed fishing with trained observers in spotter aircraft. The great value of the rapport which can exist between a vessel skipper and spotter was illustrated when on one occasion the spotter pilot directed the purse seining of a 90-t school which the skipper was unable to see until the pursing had been completed.

The need for company or more general spotting was discussed and though the aircraft spotter had been able to advise small-boat fishermen of schools in their vicinity in the course of his flights, it could pay these fishermen to combine in chartering aircraft for their own purposes.

Industrial Development

The Ministry of Agriculture and Fisheries was criticised for devoting too much research effort to skipjack, but it was pointed out that a great deal of effort is being expended on other pelagic species. In fact the successful establishment of the troll fishery for albacore involved considerable research effort over several years. Similarly, research on the biology and behaviour of other species such as trevally, jack mackerel, and kahawai has been done and is continuing, both with the research vessels and in collaboration with local purse seiners and trawlers.

Similar criticism was directed at the attention given to the foreign vessels, but again it was stressed that during the charter period they were New Zealand flag vessels operating under local regulations, and that research staff also worked with local vessels.

It was repeated that to prove the resource and the scale of fishing that it might withstand it was necessary to use vessels big enough not only to catch large quantities of fish, but to hold them. The present local storage and processing facilities are totally inadequate to cope with the large quantities of fish which were caught, and which it was necessary to show could be caught.

It was argued that almost all of the fish caught were taken out of New Zealand and that, therefore, there was no revenue from them. However, because of the size of the resource and the migratory behaviour of the fish, it was shown that these fish, if not caught by the large seiners, would have been lost in any case. The actual revenue to the country or to the NZPFDC was not given, as this is company business. However, the results are sufficiently encouraging for them to contemplate acquiring a purse seine vessel for the forthcoming season.

Several speakers pointed out that even with the necessary capital available no suitable craft could be built by New Zealand shipyards within 2 or 3 years, though there is already urgency to catch fish in quantity now. Therefore the Government should consider permitting the importation of secondhand vessels or agree to the construction of new craft overseas if they could be supplied more quickly. [Since the conference was held Government has agreed to the importation of a limited number of secondhand vessels and the construction of some others overseas.] Even so, the operation needs to be developed with care because of uncertainty about the variability of abundance of fish from year to year and the high cost of the catching units.

The use to which such large specialised craft as the Californian purse seiners might be put in the off season still needs to be worked out, particularly if they are to be crewed by New Zealanders, who might be expected to spend several months away from their base ports.

Experience with these purse seiners has shown the need for good back-up services. Many fishing days were lost because of mechanical problems that required replacement parts to be flown out from the United States.

The respective merits of medium sized vessels of about 120 ft (36 m) and large 200-ft (61-m) craft were discussed at length, as were the merits of American versus Norwegian styles of purse seining. Concerning the latter, some speakers felt that in the rougher New Zealand waters the use of a dory is an additional hazard which limits the days on which fishing can take place, but others believed that a dory has its advantages, for example, when hauling the seiner out of its net. Smaller New Zealand-based craft with limited carrying capacity have operated successfully year-round on a variety of pelagic species and supported a modest expansion of the local industry. On the other hand the larger vessels have shown that it is possible rapidly to build up catches and exports of whole fish. If this scale of operations can be sustained, development of a local tuna canning industry will be feasible.

Processing and Marketing

At present the New Zealand canning industry can absorb only small quantities of tuna and does not have the storage capacity to cope with large seasonal inputs. Considerable additional capital will be required to permit a large expansion. Though more modest developments may be desirable over the long term, the probable advent of the 200-mile economic zone has altered the situation. There is now a need to establish fishing rights to substantial quotas and this has resulted in a conflict between those anxious to expand and develop existing facilities and those who see a need to provide now for the expected large catches.

The need for high fish quality for processing and the costs of transport from fishing unit to factory were stressed. The need for a price differential between fish landed at outports (on which freight would have to be charged) and those landed to the processing plants was discussed. It was pointed out that the fishermen can make their own judgment as to whether they land locally for reduced prices or carry their loads to the factory ports, where they would receive better prices.

Similarly, large companies should have the option of selling whole fish to foreign markets or landing their fish in New Zealand for processing and resale, though it has to be recognised that canned tuna landed into United States markets are subject to import tariffs. Whether more suitable markets can be found in other countries should also be left to the judgment of the fishing companies. It was suggested that the right of foreign nations to fish within the economic zone may be used as a bargaining point for the entry of New Zealand-caught fish into their markets.

Research Studies

With respect to the adequacy of current research and what new aspects require study, there was general satisfaction with the work done so far. Coverage is not as comprehensive as it should ideally be because of limitations on the number of staff available for observations at sea. Until adequate data are available from several seasons' operations it will not be possible to determine what the average annual catch might be; so observations will continue as at present.

In terms of additional work it is most essential to engage in studies of bait-fish, their biology and behaviour, methods of catching, storing, transport, and so on. The Fisheries Research Division will try to begin such studies as soon as resources allow.

The duration of the fishing season might be extended by catching skipjack during their migrations to and from New Zealand, though there is some doubt that they will be purse seinable during their northward migration. Observations will be made from *James Cook* to the north of New Zealand during the 1976-77 season to locate surface schools of fish. Aerial surveys will continue and, if possible, be extended over the next few years to widen our knowledge of the distribution and abundance of the fish on both coasts of the North Island.

It is expected that research staff will collaborate with other scientists in the joint IPFC/SPC skipjack programme and some tagging will be done as an aid to understanding the movements of the fish. This project is being co-ordinated by Dr Robert Kearney, who is at present financed by the International Centre for Living Aquatic Resources Management, which is providing the necessary support to enable planning to go ahead. He is seeking financial support for the programme from various donor nations, including New Zealand, which has already signified its intention to contribute.

The need to identify separate stocks and to determine the extent of the total resource of the region is of considerable importance, and again the research staff will be engaged in providing material and data as part of an international programme.

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